



NASA SP-7020(01)

# LUBRICATION, CORROSION and WEAR

A CONTINUING BIBLIOGRAPHY  
WITH INDEXES

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# LUBRICATION, CORROSION and WEAR

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

A Selection of Annotated References to Unclassified Reports and Journal Articles Introduced into the NASA Information System during the period April, 1965—August, 1966.



*Scientific and Technical Information Division*

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# INTRODUCTION

With the publication of this first supplement, NASA SP-7020(01), to the original issue of the Continuing Bibliography on "Lubrication, Corrosion and Wear" (SP-7020), the National Aeronautics and Space Administration continues its program of periodic distribution of selected references to subjects of interest to the aerospace community. The references are assembled in this form to provide a convenient source of information for use by scientists and engineers who need this type of specialized compilation. Continuing Bibliographies are updated periodically by supplements which can be appended to the original issue.

NASA SP-7020(01) presents a selection of annotated references to unclassified reports and journal articles that have been announced in Scientific and Technical Aerospace Reports (*STAR*), or in International Aerospace Abstracts (*IAA*). The variety of special lubrication, corrosion, and wear problems, that arise in connection with the design and development of equipment and materials for use in the unique environment of space, has created numerous research programs to investigate and solve these problems. The references contained in NASA SP-7020(01) reflect this variety and cover such diverse topics as lubricating systems; design and performance of bearings; special applications of lubricants, e.g., as heat transfer and anticorrosion agents; stress corrosion and fatigue cracking in metals and alloys; friction and wear characteristics of materials; and finally, types of corrosion and techniques for corrosion prevention. A limited number of references describing the instrumentation and methods for the testing of lubricants is also included.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. All report literature references appear in the first group and are subdivided according to their date of announcement in *STAR*. The second group contains published literature references subdivided according to their date of announcement in *IAA*. All reports and articles cited were introduced into the NASA Information System during the period April, 1965 - August, 1966.

A subject index and a personal author index are included.

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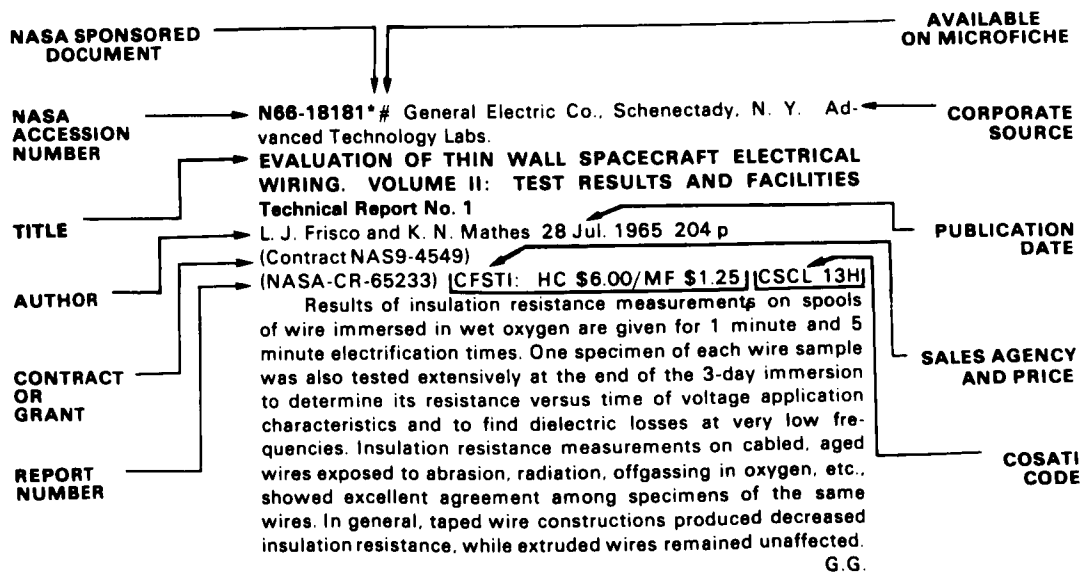
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## TYPICAL CITATION AND ABSTRACT





# LUBRICATION CORROSION and WEAR

*a continuing bibliography* OCTOBER 1966

## 1965 STAR ENTRIES

**N65-13415** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**CORROSION RESISTANCE OF IRON-ALUMINUM ALLOYS IN FLUORINE AT TEMPERATURES OF 500°—700°**  
M. A. Stepanov, A. V. Kurdyumov and V. N. Goloborodov  
*In Its Nonferrous Met.* 29 Jun. 1964 p 231-238 refs (See N65-13401 04-17)

As the aluminum content in iron-aluminum alloys is increased from 5.5% to 31%, the hardness increases from 166 to 444 units on the Brinell scale. Tests established that the corrosion resistance of all the alloys is very low in fluorine at elevated temperatures. At 500°C the corrosion rate is determined in tens of grams/m<sup>2</sup>-hour, while at higher temperatures (600° to 700°C) destruction proceeds even more intensively.  
D.S.G.

**N65-13791#** IIT Research Inst., Chicago, Ill.  
**RESEARCH ON THE BASIC NATURE OF STRESS CORROSION FOR VARIOUS STRUCTURAL ALLOYS AT ROOM AND ELEVATED TEMPERATURE**  
F. A. Crossley Wright-Patterson AFB, Ohio, AF Mater. Lab., May 1964 79 p refs  
(Contract AF 33(657)-10971)  
(ASD-TR-61-713, Pt. III; AD-605703)

Wrought, high-strength aluminum alloys characteristically have markedly inferior resistance to stress corrosion in the short-transverse direction relative to resistance in the longitudinal and long-transverse directions. The anisotropy of resistance is due to marked anisotropy of microstructure. Investigation of experimental and commercial 1-in. plate showed that the elongated, platelike grain structure usually found in commercial materials was associated with short life, whereas equiaxed or irregular grain structure was associated with significantly longer life. Excess alloy content resulting in second-phase particles in the microstructure contributes to the development of the undesirable elongated grain structure. Exposure at 650° F under stress for times of 1400 or 2000 hr gave no indication that the steels PH 13-8 Mo and PH 14-8 Mo are susceptible to hot salt stress corrosion. Experiments to determine the kinetics of hot salt stress-corrosion cracking of Ti-8Al-1Mo-1V alloy are described.  
Author

**N65-13989#** IIT Research Inst., Chicago, Ill. Technology Center

**INTERFACE FRICTION IN HOT METAL DEFORMATION**  
**Bimonthly Report, 24 Jul.-23 Sep. 1964**

J. A. Schey 22 Oct 1964 7 p

(Contract N0W-64-0458-f)

(IITRI-B6027-2; AD-609115)

An investigation of frictional phenomena encountered at the interface of tool and workpiece during the hot deformation processing of metals is discussed. A procedure established to provide reproducible surface conditions involves the degreasing of the specimen and anvils followed by dressing on 600-grit polishing paper prior to each series of impressions. Experiments were carried out at room temperature with the best lubricant known in current technology. The forces developed in dry compression at 20°C were substantially higher than those developed with full lubrication. Compression with various anvils gave not only different forces, but also different trends. With an annealed 1095 anvil, the force required for a given reduction tends to increase for successive impressions; when using the 4340, H-11, and 304 anvils, the force decreases. A significant decrease in the force required for deformation was noted for the 304 anvils as compared with that for 4340, H-11, or 1095 anvils.  
P.V.E.

**N65-14058#** SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**INFLUENCE OF LUBRICATION ON ENDURANCE OF ROLLING CONTACTS** Progress Report No. 11, 22 Mar.-22 Jun. 1964

E. F. Brady, A. Schwartz, J. McCool, R. Valori, W. Schmidt et al [1964] 75 p refs

(Contract N0W-61-0716-c)

(AL64T057; AD-609072)

The following studies were made: *Radiotracer Wear Tests*—wear tests for polyphenyl ether lubricant, and a single wear test using the base stock of a Mil-L-23699 lubricant; *Autoradiographic Particle Size Measurement in the Investigation of Wear in Rolling Contacts*; *Autoradiographic Study of Metallic Transfer in Rolling Contact*; *Surface Geometry Analysis of As-Ground Balls*—surface roughness, calibration constants, and calculations; *Conductivity Testing on Four-Ball Tester*—conductivity for the Mil-L-23699 base oil and the base mineral oil (Primol 355), and a conductivity test using as-ground balls; *Film Profile Measurements*—effect of speed on the lubricant film, film profiles at different angular orientations, and contact conductivity measurement on the two-ball tester; *Endurance Effect of Hydrodynamic Films*—plastic deformation of ball tracks.  
G.G.

**N65-14123#** Battelle Memorial Inst., Columbus, Ohio. Defense Metals Information Center

**BERYLLIUM REVIEW OF RECENT DEVELOPMENTS**

Hugh D. Hanes 6 Nov. 1964 3 p refs

A survey is given of studies on the deformation characteristics of beryllium single crystals and the effects of iron and silicon additions on these characteristics, on the tensile properties of beryllium extrusions of various grain sizes at different temperatures, on the corrosion of beryllium by high-temperature air, on the corrosion resistance of beryllium in high-temperature water, and on the reactions of beryllium with nitrogen, air, oxygen, and carbon monoxide at high temperatures. The development of a series of beryllium-aluminum alloys for compression applications in spacecraft is reported, and the dimensional stabilization of extrusions by warm drawing is described. Extrusion and other methods of forming angle beams and tubing are discussed. Techniques for producing spherical beryllium powder by atomizing directly from the melt are mentioned. The substitution of beryllium for fused silica in spacecraft optics is recommended. D E W

**N65-14144#** Socony Mobil Oil Co., Inc., Paulsboro, N.J. **STUDY AND EVALUATION OF THE OXIDATIVE AND DEPOSIT-FORMING PROPERTIES OF HIGH TEMPERATURE LUBRICANTS** Technical Documentary Report, 1 Aug. 1963-31 Mar. 1964

S. J. Leonardi and E. A. Oberright Wright-Patterson AFB, Ohio, AF Aero Propulsion Lab., Nov. 1964 16 p  
(Contract AF 33(657)-11741)  
(ASD-TDR-62-222, Pt. III; AD-609318)

A series of high-temperature oils was evaluated in a high-temperature thin-film oxidation unit. The apparatus measures oxygen consumption and deposits formed by the oils in thin films on a rotating heated disk. Data were obtained at several film thicknesses and contact times which were varied by changing the rate at which the oil is passed over the disk. At the optimum oil flow rate, correlation of disk cleanliness with engine deposition data was excellent. A brief exploratory study indicated that provision for bulk oxidation in addition to the high-temperature thin-film oxidation could further improve the thin-film oxidation unit as a screening tool. Author

**N65-14222#** IIT Research Inst., Chicago, Ill. Technology Center **INTERFACE FRICTION IN HOT METAL DEFORMATION** Bimonthly Report, Sep. 24-Nov. 23, 1964  
J. H. Schey 22 Dec. 1964 10 p refs  
(Contract N0w-64-0458-F)  
(IITRI-B6027-3; AD-454402)

The objective of this program was to investigate frictional phenomena encountered at the tool-workpiece interface during the hot deformation processing of metals. Work centered around the establishment of a reference base and the compression of 7075 Al with 1090, 4340, H-11, WC (10%Co), TZM, and Al<sub>2</sub>O<sub>3</sub> anvils. Exploratory experiments with 4340 and 4130 steels and Inconel X750 were also conducted. Author

**N65-14228#** General Electric Co., Evendale, Ohio. Advanced Engine and Technology Dept. **INFLUENCE OF STRESS CORROSION ON STRENGTH OF GLASS FIBERS**  
D. L. Hollinger, W. G. Kanetzky, and H. T. Plant 30 Sep. 1964 12 p  
(Contract Nonr-4486(00) (X))  
(BMPR-3; AD-607040)

Initial static fatigue tests at liquid nitrogen temperature on single filaments of E-glass yielded incomplete data because of frost buildup problems. It became necessary to isolate the equipment from room humidity. This has been done, and low temperature testing has resumed successfully, with delayed failure data accumulating at a satisfactory rate. The results so far indicate that even with the very high rates of loading used in these tests, the stress level at which most

fibers will fail immediately is lower at room temperature and normal humidity than at liquid nitrogen temperature. Gradually raising the temperature from liquid nitrogen temperature causes the failure of fibers which have been supporting a given load at -196°C. The implication is that the processes involved in static fatigue are greatly slowed down, but not completely eliminated, by lower temperatures in the range from room temperature to -196°C. Author

**N66-14327\*#** National Academy of Sciences—National Research Council, Washington, D. C. Space Science Board. **SPACE RESEARCH: DIRECTIONS FOR THE FUTURE. PART ONE: PLANETARY AND LUNAR EXPLORATION** Dec. 1965 144 p refs Rept. of Summer Study held at Woods Hole, Mass., Jun.-Jul. 1965  
(Contract NSR-09-012-903)  
(NASA-CR-69076) CFSTI: HC \$4.00/MF \$0.75 CSCL 22A

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22. INTERACTION OF THE SOLAR WIND WITH THE PLANETS P. J. Coleman, Jr. p 127-139 refs (See N66-14334 05-29)

**N65-14379#** Olin Mathieson Chemical Corp., New Haven, Conn. Chemicals Div. **DEVELOPMENT OF NONFLAMMABLE HYDRAULIC FLUIDS AND LUBRICANTS** Bimonthly Progress Report, Aug. 18-Oct. 17, 1964  
H. F. Lederle 29 Oct. 1964 26 p refs  
(Contract NObsr-90092)  
(BMPR-6; AD-607489) OTS: \$2.00

The addition of ethylene oxide or glycidol to tetrameric bis (p-hydroxyphenoxy) phosphonitrile resulted in the formation of water-soluble fluid products. The synthetic method for tetrameric bis (p-nitrophenoxy) phosphonitrile—an intermediate for water-soluble products—and improved procedure for the chloromethylation of trimeric bis (phenoxy)-phosphonitrile, and a method for converting the chloromethylated product to the corresponding hydroxymethyl compound were developed. Trimeric N-methyl-m-chloroanilino-2,2,2-trifluoroethoxy-phosphonitrile was prepared. This compound had a spontaneous ignition temperature slightly higher than trimeric N-methyl anilino-2,2,2-trifluoroethoxy-phosphonitrile. Utilization of a trimer-tetramer phosphonitrilic chloride mixture in place of the pure compounds for the synthesis of substituted aryloxy-2,2,2-trifluoroethoxy phosphonitriles was investigated and found to be feasible. Author

**N65-14411#** Springfield Armory, Mass.  
**EFFECT OF ULTRASONIC CLEANING ON CORROSION RESISTANCE OF PHOSPHATE-COATED PANELS**

M. S. Spivak 2 Oct 1964 22 p  
 (SA-TR16-1122; AD-450566)

Zinc and manganese phosphated steel panels were exposed to high frequency vibrations (ultrasonic cleaning) in various media to determine the effect of this cleaning procedure on the corrosion resistance of the coated panels. Phosphated panels showed diminished corrosion resistance after exposure to these vibrations in water and water-based cleaners, but were not affected after exposure to ultrasonics when trichloroethylene was used as the medium. Phosphate-coated panels ultrasonically cleaned and then treated with supplementary oil (MIL-L-644) exhibited relatively the same corrosion resistance as oiled phosphated panels not exposed to ultrasonic vibrations. Test procedure is given and results are discussed. Author

**N65-14696#** European Atomic Energy Community, Brussels (Belgium).

**RESEARCH CARRIED OUT UNDER THE EURATOM/UNITED STATES AGREEMENT**

P. Kruys et al 1964 180 p refs  
 (EUR-1840.e) Available from Belg. Am. Bank and Trust Co., N.Y., account no. 22.186; 250 Belg. Fr.

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3. THE CAUSES OF EMBRITTLEMENT IN STEELS FOR NUCLEAR REACTOR VESSELS Jean Sebillé p 111-154 refs
4. EURATOM'S ACTIVITY IN THE FIELD OF URANIUM OXIDE P. Fernet p 155-180 refs

**N65-14870#** Du Pont de Nemours (E.I.) and Co., Aiken, S.C. Savannah River Lab.

**MICROPROBE STUDY OF ZIRCALOY CORROSION FILMS**

Kurt F. J. Heinrich Nov. 1964 46 p refs  
 (Contract AT(07-2)-1)

(DP-906) OTS: \$2.00

The primary object of this study was to determine the potential usefulness of the electron probe analyzer as a tool for the investigation and elucidation of problems in the corrosion of zirconium alloys, particularly Zircaloy-2. The general applicability of the probe to corrosion studies was demonstrated. Techniques were developed for the preparation and study of corroded zirconium alloy specimens. Previously unknown characteristics of the distribution of the component elements

were revealed in Zircaloy-2 specimens and other zirconium alloys which had been subjected to various heat treatments. Data were also obtained on the composition and distribution of alloy elements in the fundamental corrosion layers. The possible significance of these findings is discussed in the light of current theories on corrosion mechanisms in zirconium alloys. Author

**N65-15136#** Boeing Co., Renton, Wash. Airplane Div.  
**INVESTIGATION OF THE EFFECTS OF STRESS CORROSION ON HIGH-STRENGTH STEEL ALLOYS**

Gary A. Dreyer and Wesley C. Gallagher Wright-Patterson AFB, Ohio, AF Mater. Lab., Feb. 1964 129 p refs  
 (Contract AF 33(657)-8705)  
 (ML-TDR-64-3; AD-605672)

The stress corrosion susceptibility of several high strength steels has been evaluated by alternate-immersion laboratory testing in a 3.5% sodium chloride solution. The steels evaluated were the stainless steels AFC 77, AM 350, AM 355, and 17-4PH; the low alloy steels D6AC, 4335M, 4340, H-11, 4330 M, and HY-Tuf; and the high nickel steels 18Ni-9Co-5Mo, 18Ni-7Co-5Mo, and 9Ni-4Co. The variables investigated were product form, grain direction, tensile strength level, stress level, cold working, ausforming, welding, and protective coatings. Detailed results relating stress-corrosion susceptibility to the variables and alloys studied are included. Notch-tensile and fatigue-cracked fracture-toughness testing was carried out for correlation with stress-corrosion susceptibility. Optical microscopy, electron microscopy, and X-ray diffraction studies were made to supplement the mechanical property and stress corrosion testing. A literature survey or related stress corrosion test data is included. Author

**N65-15833#** Naval Research Lab., Washington, D.C.  
**STEEL CORROSION MECHANISMS. THE GROWTH AND BREAKDOWN OF PROTECTIVE FILMS IN HIGH-TEMPERATURE AQUEOUS SYSTEMS: STUDIES WITH 15% NaOH AT 316° C**

M. C. Bloom, G. N. Newport, and W. A. Fraser 17 Apr. 1964 13 p refs  
 (NRL-6082; AD-608334) OTS: \$1.00

This report summarizes what is known regarding the reaction of steel with high-temperature water as affected by sodium hydroxide additions, and also presents results of a detailed study, using the hydrogen effusion method, of the reaction of steel with 15 percent sodium hydroxide solution at 316° C. The corrosion rates are correlated with a microscopic study of the growth and breakdown of the protective magnetite (Fe<sub>3</sub>O<sub>4</sub>) film. There are two different corrosion-rate-governing mechanisms involved prior to the onset of pitting: a large decrease of the initial corrosion controlled by the buildup of a protective film on the metal surface, and a subsequent smaller decrease in corrosion rate possibly controlled by penetration of the magnetite film by the corrosive solution. The pitting is apparently due to the genesis of cracks in the magnetite film after it reaches a critical thickness. Author

**N65-15846#** Olin Mathieson Chemical Corp., New Haven, Conn. Chemicals Div.

**DEVELOPMENT OF NONFLAMMABLE HYDRAULIC FLUIDS AND LUBRICANTS Final Report, Oct. 1963-Oct. 1964**

E. H. Kober, H. F. Lederle, and G. F. Ottmann 17 Nov. 1964 72 p refs

(Contract NObs-90092)

(AD-608144) OTS: \$3.00

A large number of trimeric and tetrameric aryl-1,1-di-H-polyfluoroalkyl phosphonitrilates was synthesized and evaluated. Several of these products meet or approach the requirements for pour point, volatility, viscosity, density, spontaneous ignition temperature, and thermal and hydrolytic stability; these

compounds also display excellent wear properties. Several trimeric and tetrameric arylamino-polyfluoroalkoxy phosphonitriles were prepared. The properties of a few representatives of this novel class of compounds come close to meeting the requirements for naval hydraulic fluids. Addition of ethylene oxide or glycidol to hydroxy-aryloxy- or amino-aryloxy-phosphonitriles gave water-soluble products that have potential for use in water-base hydraulic fluids. Author

**N65-15986#** SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**INFLUENCE OF LUBRICATION ON ENDURANCE OF ROLLING CONTACTS** Final Summary Report, Jun. 22, 1961-Jun. 22, 1964

K. Tataiah et al [1964] 197 p refs  
(Contract N0w-61-0716-c)  
(AL64TO67, AD-609437)

A study of elastohydrodynamic lubricant film effects in rolling ball two-ball contacts is presented. Mineral oils, ester base, and polyphenyl ether lubricants with and without lubricity additives were studied. The experimental work covered the development and application of contact conductivity and X-ray beam transmission measurements for film thickness and profile determination, radiotracer wear rate determination, microautoradiography of wear debris and of metal transfer, instrumental analysis of surface microgeometry, and rolling contact fatigue test series. A tentative analysis of wear debris size distribution is given. Microautoradiography is used to show that there is direct metal transfer in lubricated sliding ball contact, but only wear debris redeposition from the lubricant in rolling contact. Some measurements of film thickness and shape by X-ray beam transmission are reported. Author

**N65-16124#** Pratt and Whitney Aircraft, East Hartford, Conn.

**SOLID FILM LUBRICATED BEARING RESEARCH PROGRAM** Technical Documentary Report, 1 May 1963-30 Jun. 1964

Paul Brown, Roger M. Hawkins, M. Maguire, and M. Pitak Wright-Patterson AFB, Ohio, AF Flight Dyn. Lab., Oct. 1964 211 p refs  
(Contract AF 33(657)-10420)  
(PWA-2354; FDL-TDR-64-117; AD-608629)

The program was divided into two phases. The first phase consisted of analytical evaluations of potential bearing designs, solid lubricant materials and lubricant supply systems as applied to accessory-sized ball bearings. The second phase was devoted to laboratory determinations of lubricant materials tensile strength and thermal properties followed by evaluations of selected solid lubricant materials and bearings. These tests included friction and wear evaluations of both lubricant and bearing materials in a friction and wear rig; evaluations of full-scale bearings in atmospheric and vacuum environments at temperatures ranging from  $-249^{\circ}$  to  $1500^{\circ}$  F, at speeds up to 24000 rpm for periods up to 3 hours; and vacuum-environment testing of bearings that were exposed to a fast neutron dose of approximately  $1.0 \times 10^{17}$  neutrons/cm<sup>2</sup> ( $> 1.0$  MeV). Test results indicated that no lubricant tested, regardless of the supply system used or conditions under which tested, showed any clear superiority when compared to other dry film lubricants. Author

**N65-16201#** Mechanical Technology, Inc., Latham, N.Y.  
**LUBRICATION ANALYSIS IN TURBULENT REGIME** Second Quarterly Report

F. K. Orcutt, C. W. Ng, J. H. Vohr, and E. B. Arwas 30 Jan. 1965 82 p refs  
(Contract NASw-1021)

(NASA-CR-54259; MTI-65TR2) OTS: HC \$3.00/MF \$0.75

The preloaded tilting-pad bearing was tested experimentally. Measurements of static load capacity and shaft response to dynamic loading agreed very well with calculated values, and the theoretical results were quite adequate for design analysis. Measured torques were uniformly higher than the calculated values. The analysis for static load properties of the floating-ring bearing was completed, and some numerical results are presented. Apparatus modification and preliminary experiments are reported on some studies of fundamental processes of superlaminar flow in concentric and eccentric annuli. D.E.W.

**N65-16293#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**CORROSION RESEARCH**

4 Dec. 1964 73 p refs Transl. into ENGLISH from Korrozios Figyelo (Hungary), v. 3, no. 7, 1963 p 125-159  
(FTD-TT-64-730/1+2+3+4; AD-455531)

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**N65-16634#** Bureau of Mines, Rolla, Mo. Rolla Metallurgy Research Center

**EFFECTS OF SUBSTITUTING COBALT FOR NICKEL ON THE CORROSION RESISTANCE OF TWO TYPES OF STAINLESS STEEL**

Milton M. Tilman 1965 21 p refs  
(BM-R1-6591)

The effects of substituting cobalt for nickel on the acid corrosion resistance of two types of austenitic stainless steel were determined. Cobalt substitutions to a maximum 22 weight percent were made in types 302 and 309 stainless steels. Total immersion corrosion tests were made in 10 volume-percent hydrochloric acid, and boiling-acid tests were conducted in 65 weight-percent nitric acid and in undiluted glacial acetic acid. For modified type 309 in acetic acid, corrosion rates decreased for additions greater than 0.57 weight-percent cobalt. Corrosion rates increased as cobalt was increased up to about 1 weight percent for modified type 302 in nitric and hydrochloric acids and for modified type 309 in nitric acid, but these rates decreased with a further increase in cobalt content. A gradual increase in corrosion rates with increasing cobalt content was shown for type 302 in acetic acid and for type 309 in hydrochloric acid. Author



- N65-16667#** Aluminum Co. of America, New Kensington, Pa. Alcoa Research Labs  
**INVESTIGATION OF THE MECHANISM OF STRESS CORROSION OF ALUMINUM ALLOYS** Quarterly Report, Jun. 1–Nov. 30, 1964

G. C. English and J. McHardy [1964] 45 p refs  
 (Contract N0w-64-0170-c)  
 (QR-3; AD-608842)

Extensive measurements were made upon 2-inch thick 7075 alloy plate in two tempers, one susceptible to stress corrosion, and one not susceptible. For these measurements, specimens taken in the short-transverse direction, to provide maximum susceptibility, were tested in an aggressive electrolyte consisting of an aqueous solution of chlorides acidified to pH 1. In this electrolyte, a susceptible specimen stressed to 75% of its yield strength failed by stress corrosion in approximately 1 hour, and a stressed, nonsusceptible specimen failed by general corrosion in 48 hours or less. Two pertinent potentials of cathodic protection were found, the first one 150 mV negative to the corrosion potential, and the second, and much more sharply defined one, 575 mV negative to this potential. Pitting ceased when a specimen was polarized cathodically beyond the first potential, but polarization to the second potential was required to eliminate stress corrosion.

Author

- N65-16736** Joint Publications Research Service, Washington, D C

**ONE OF THE REQUIREMENTS OF AUSTENITIC HEAT-RESISTING STEELS FOR POWER MACHINE BUILDING** V. N. Gulyayev. In: Properties of Heat-Resisting Steels for Heat and Power Eng. 11 Feb. 1965 p 51–59 refs (See N65-16731 07-17) OTS \$3.00

Corroded sites in a high-pressure steam system were examined, and samples of similar austenitic steel were treated and tested. It is concluded that, for use in a steam medium, it is advisable to use austenitic steels without stabilizing additions of niobium and titanium. Steels with these elements are necessary if the working medium is steam condensate. Steels that are susceptible to intercrystalline corrosion are especially susceptible to the presence of oxygen and chlorine ions in the water.

D. E. W.

- N65-16745\*#** General Electric Co., Cincinnati, Ohio. Missile and Space Div.

**POTASSIUM CORROSION TEST LOOP DEVELOPMENT** Quarterly Progress Report No. 5, Jul. 15–Oct. 15, 1964 E. E. Hoffman, ed. 30 Dec. 1964 58 p refs  
 (Contract NAS3-2547)

(NASA-CR-54269) OTS: HC \$2.00/MF \$0.50

The immediate corrosion test design conditions for a two-loop Cb-Zr facility are (1) boiling temperature, 1900° F; (2) superheat temperature, 2000° F; (3) condensing temperature, 1350° F; (4) subcooling temperature, 800° F; (5) mass flow rate, 20 to 40 lb/hr; (6) vapor velocity, 100 to 150 ft/sec; and (7) average heat flux in the potassium boiler, 50000 to 100000 BTU/hr ft<sup>2</sup>. Two test loops were completed and a third is under construction, for sequential testing of components and endurance. Loop I, a natural convection loop, was operated for 1000 hours with liquid sodium at a maximum temperature of 2260° to 2380° F. Evaluation electrical components and characteristics and the use of electrical and thermal insulation was done in the Loop I test. Loop II provides for evaluation of single-phase forced-circulation sodium flow components and pressure transducers. The design was completed for a prototype corrosion test loop. This is a two-loop system including the Loop I and II components and a boiler, turbine simulator, and condenser for development and endurance testing of the components in stable operation at the corrosion test design conditions.

E. P. V.

- N65-16765#** Houghton (E. F.) and Co., Philadelphia, Pa.  
**DEVELOPMENT OF FIRE RESISTANT WATER BASED HYDRAULIC FLUIDS**

Philip Rakoff, G. John Colucci, and Robert K. Smith 27 Nov. 1964 26 p

(Contract NObsr-90269)  
 (BMR-4; AD-608564)

The study of ignition inhibitors for water glycol fluids was continued, with emphasis on noncrystalline compounds. A search for better screening methods of corrosion inhibitor system in the target fluids was started. One candidate fluid was examined with respect to the target specification.

Author

- N65-16825#** Southwest Research Inst., San Antonio, Tex. Dept. of Aerospace Propulsion Research  
**FUNDAMENTAL STUDIES OF CONTACT FATIGUE** Progress Report No. 3, Oct. 24, 1964–Jan. 24, 1965

R. A. Burton and J. A. Russell 24 Jan. 1965 53 p ref  
 (Contract N0w-64-0460-d)

(RS-441; AD-455439)

Experiments are described for lubricated and unlubricated 52100 tool steel contacts under high frequency oscillatory normal load at Hertz stresses from 375000 to 720000 psi. The effect of several different lubricants on fatigue life and on contact wear is demonstrated. Statistical analysis of fatigue life data shows significant differences between lubricant types.

Author

- N65-17022#** Defence Research Lab., Kanpur (India).  
**VOLATILE CORROSION INHIBITORS AND THEIR CURRENT APPLICATIONS**

S. K. Gupta and B. Sanyal [1962] 27 p refs

A description is given of the mechanism of protection, advantages of VCI preservation methods, chemicals possessing vapor phase inhibiting property, commercial VCI's, results of practical trials with VCI's, specification for VCI-treated packaging materials, work done in DRL(M) Kanpur, India, how VCI's are used, precautions to be observed while using VCI's, and current application of VCI's.

Author

- N65-17187#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**TENDENCY OF STEEL TOWARD CORROSION CRACKING IN VARIOUS MEDIA**

F. F. Azhugin and Yu. K. Pavlov 9 Dec. 1964 10 p refs  
 Transl. into ENGLISH from Korroziya i Zashchita Metallov, Sbornik Statey, Oborongiz (Moscow), 1962 p 112–117  
 (FTD-TT-64-643/1+2; AD-610344)

The dependence of time, up to the appearance of cracks, upon the magnitude of applied tensile stresses within limits of elastic deformations for many instances of corrosion cracking of soft and high strength steels, magnesium, aluminum, and copper alloys in various media has a hyperbolic nature and is sufficiently accurately expressed by the equation of the corrosion cracking curve.

$$(\delta - \delta_{CR}) \tau = K$$

Critical stresses  $\delta_{CR}$  and the constant K appear to be quantitative characteristics of the alloy's tendency toward corrosion cracking. Investigations were carried out on various samples of steel. Results show that the tendency of steel toward corrosion cracking during the pickling in acid depends largely upon its composition.

E. E. B.

- N65-17276\*#** Midwest Research Inst., Kansas City, Mo.  
**DEVELOPMENT OF SOLID FILM LUBRICANTS FOR USE IN SPACE ENVIRONMENTS**

Vern Hopkins and Donald Gaddis [1963] 12 p. Presented at 1963 USAF Aerospace Fluids and Lubricants Conf., San Antonio, 16–19 Apr. 1963

(Contract NAS8-1540)  
 (NASA-CR-60783) OTS: HC \$1.00/MF \$0.50

Friction coefficients are given for many potential lubricants subjected to a light load and temperatures from 80° to 400° F, in both a normal air atmosphere and in a vacuum of  $10^{-6}$  torr. The main criterion for judging the performance of a potential lubricant film was the friction coefficient, which must be less than that obtained for a 0.001-in. thick film of gold. The following lubricant films exhibited lower overall friction coefficients than a 0.001-in. thick gold film: MoS<sub>2</sub> + graphite + bismuth/sodium silicate; MoS<sub>2</sub> + graphite + gold/sodium silicate; MoS<sub>2</sub> + graphite + molybdenum/sodium silicate; MoS<sub>2</sub> + graphite/sodium silicate; and MoS<sub>2</sub> + graphite/sodium phosphate. Author

**N65-17328\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**EVALUATION OF FIVE BEARING-SEPARATOR MATERIALS AND POLYPHENYL ETHER LUBRICANTS FOR USE IN SPACE POWER GENERATION SYSTEMS**

William R. Loomis Washington NASA, Mar. 1965 18 p refs (NASA-TN-D-2663) OTS: HC \$1.00/MF \$0.50

The suitability of five bearing-retainer materials (iron-silicone bronze, S-Inconel, Stellite Star-J, M-2, and M-50) for ultimate use in the mainshaft rolling-element bearings of the SNAP-8 space power generation system was determined in a series of friction and wear experiments. Polyphenyl ether lubricant (type 4P3E) was supplied at 250° F from a drip-feed, once-through system at a rate sufficient to maintain boundary lubricating conditions. The specimen configuration consisted of a hemispherical rider (3/16-in. rad., representing the retainer) sliding at 3600 feet per minute against the flat surface of a rotating disk (2 1/2-in.-diam M-50 high-speed tool steel, representing the raceway and the rolling element) ~300° F. Minimum friction coefficients and the lowest total disk and rider wear were obtained with the iron-silicon bronze specimen, but the other four retainer materials had acceptable friction properties and rider wear volumes in the same order of magnitude as the bronze. Author

**N65-17412#** Pacific Naval Lab., Esquimalt (British Columbia). **PRINCIPLES OF DESIGN OF CATHODIC PROTECTION SYSTEMS FOR THE HULLS OF ACTIVE SHIPS**

J. A. H. Carson Sep. 1964 48 p refs (Rept.-64-2)

An engineering approach to the design of cathodic protection systems for ships' hulls is presented. The method is applicable to all types of anode systems. The effects on current requirements of dissolved oxygen concentration, ship speed, temperature, salinity, type and condition of hull paint system, metallic bonding of rotating propellers to the hull, and efficiency of current distribution, are discussed. Methods are developed for estimating both the maximum current output capability and the safe current output of anodes, and are presented graphically for easy reference. Sample calculations are given, and the theoretical developments are supported, wherever possible, by data obtained from RCN ships. Author

**N65-17429#** ARO, Inc., Arnold Air Force Station, Tenn. **OPERATIONAL EVALUATION OF DRY THIN FILM LUBRICATED BEARINGS AND GEARS FOR USE IN AEROSPACE ENVIRONMENTAL CHAMBERS, DECEMBER 7, 1963-JANUARY 27, 1964**

T. L. Ridings Arnold Eng. Develop. Center, Feb. 1965 54 p refs (Contract AF 40(600)-1000) (AEDC-TR-65-1; AD-456990)

Test results indicate that dry, thin film lubricants and soft metal plating lubricants can be applied satisfactorily to certain types of bearings and gears, and are capable of sustaining heavy loads at slow speeds in space environments. Author

**N65-17459\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**INFLUENCE OF CRYSTAL STRUCTURE ON THE FRICTION AND WEAR OF TITANIUM AND TITANIUM ALLOYS IN VACUUM**

Donald H. Buckley, Thomas J. Kuczkowski, and Robert L. Johnson Washington, NASA, Mar. 1965 16 p refs (NASA-TN-D-2671) OTS: HC \$1.00/MF \$0.50

The friction and wear characteristics were determined in vacuum (to  $10^{-9}$  mm Hg) for titanium and titanium alloys sliding on themselves and on 440-C stainless steel. The titanium alloys included titanium-tin, titanium-oxygen, and titanium-zirconium. The influence of tin and oxygen on the lattice parameters of titanium and its friction and wear characteristics were measured. The effect of crystal transformation from a hexagonal to a cubic form for a zirconium-titanium alloy was also studied. Friction and wear experiments were conducted with a hemispherical rider sliding on a flat disk surface at loads to 1000 g and speeds to 2250 ft/min. Experiments were conducted at 75° and 425° F. While most hexagonal metals have good friction and wear properties, the results indicate that titanium, although a hexagonal metal, exhibits relatively high friction. This high friction may be related to a difference in the slip mechanisms for titanium; titanium unlike most hexagonal metals slips on the {10T0} planes rather than on the (0001) basal plane. The addition of tin or oxygen to titanium expands the crystal lattice of titanium and reduces the friction and wear characteristics. The friction coefficient obtained for a titanium-zirconium alloy markedly increased, complete seizure occurred when the material transformed from the hexagonal to the cubic form. Author

**N65-17697#** Transport Dynamics, Inc., Santa Ana, Calif. Research and Development Div.

**TYPE II FABROID 181 GLASS BACKED SIMULATED OUTER SPACE ENVIRONMENT Qualification Test**

A. Wahlberg 11 Feb. 1964 14 p (Res. Rept.-8-3008)

Prior to performing load/oscillating tests on Fabroid, the material was subjected to a simulated outer space environment of  $1 \times 10^{-10}$  torr for a continuous period of 2400 hours with no visual deterioration of the material. The tests were conducted over a two-day period after the material and test apparatus were subjected to a simulated environment of  $1 \times 10^{-8}$  torr for a total of 336 hours continuous time. Author

**N65-17860#** MSA Research Corp., Callery, Pa. **FACTORS AFFECTING THE COMPATIBILITY OF LIQUID CESIUM WITH CONTAINMENT METALS Sixth Quarterly Progress Report, Dec. 1963-Feb. 1964**

F. Tepper and J. Greer 16 Mar. 1964 15 p ref (Contract AF 33(657)-9168) (MSAR-64-27; AD-439675)

Tests with the dissimilar metal couples TD-nickel vs Nb-1%Zr, TD-nickel vs Mo-1/2%Ti, and Nb-1%Zr vs Mo-1/2%Ti have continued with metallographic, chemical, and microprobe analyses. Solubility studies on the refractory alloys Nb-1%Zr and Mo-1/2%Ti indicated that the solubilities of the major constituents are approximately 20 ppm, and that there are possible synergistic effects resulting from the presence of the alloying elements. Capsules fabricated from Haynes-25 alloy and TD-nickel showed relatively little attack from exposure to refluxing cesium at 1800° F, and Mo-1/2%Ti alloy has survived a 255-hr test at 2500° F showing some dissolution of the alloy in the boiling liquid cesium. Author

**N65-17908#** Rock Island Arsenal Lab., Ill. **THE EFFECT OF GREASE CHARACTERISTICS UPON FRETTING DAMAGE**

S. Fred Calhoun 21 Dec. 1964 11 p refs  
(RIA-64-3575; AD-610561) OTS: \$0.50

Five different greases chosen to exhibit differences in shear stability, consistency, or base oil viscosity were tested. The test specimens were of carbon steel heat treated to two degrees of hardness, and surface finished to two smoothness ranges. Another set of specimens of 1018 carbon steel, not heat treated, were also used. Tests were made on the fretting damage tester under identical conditions. The results warrant the following conclusions: (1) A shear stable grease allows more fretting damage than a shear unstable one made from the same oil and having the same initial consistency. (2) A grease made from an oil of low viscosity allows less fretting damage than one made from an oil of higher viscosity. (3) A low viscosity oil in a grease is more effective in preventing fretting damage than a grease of softer consistency but of a higher oil viscosity. It is suspected that the nature of the oil or of the soap thickener itself may have an effect upon fretting which can modify the effect of stability, consistency, or oil viscosity. Author

**N65-17992\*** General Electric Co., Cincinnati, Ohio. Missile and Space Div.

**STUDIES OF ALKALI METAL METAL CORROSION ON MATERIALS FOR ADVANCED SPACE POWER SYSTEMS**  
Quarterly Progress Report 2, 26 Sep.-26 Dec. 1964

R. W. Harrison [1964] 38 p refs  
(Contract NAS3-6012)

(NASA-CR-54281) OTS: HC \$2.00/MF \$0.50

Stress corrosion reflux capsules were designed, and supporting components for a test facility prepared to examine the influence of stress on the corrosion behavior of D-43 columbium base alloy in potassium. Measured creep strengths of D-43 alloy bar were found to be higher than those previously reported from data compilation. A boiling nucleator was designed to be used in the capsule tests in order to avoid possible deformation in the reduced wall and/or fracture of the alumina probes as a result of boiling instabilities. A comparative investigation is being made of two stainless steel alloys, Type 316SS and titanium stabilized Type 321SS, to test the ability of the titanium addition to reduce or eliminate interstitial mass transfer through potassium in a stainless steel-Cb-12r alloy bimetallic system. Columbium-1% zirconium alloy specimens are being exposed to liquid potassium in capsules of the two steels for 1000 hours at 1400° F under isothermal conditions.

R.L.K.

**N65-18075\*** Naval Civil Engineering Lab., Port Hueneme, Calif.

**IMPROVED METHOD OF DETERMINING METAL CORROSION RATE BY WEIGHT LOSS**

E. S. Matsui 16 Nov. 1964 19 p refs  
(R-341; AD-609228) OTS: \$0.75

A deficiency was found in the procedure for the salt-spray test used to determine the weight loss suffered by metal structures, such as ballast tanks, from rusting. The procedure did not take into account the nonhomogeneity of material among the panels being tested. A modified method was developed, and the results obtained with this method were compared with those obtained using the original method. The modified method not only corrected the deficiency, but it also improved the precision of the test method significantly. Author

**N65-18284\*** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**USE OF POLYMERS IN ANTICORROSIVE TECHNOLOGY**

P. G. Udyama et al [1960] 420 p refs Transl. into ENGLISH from RUSSIAN  
(FTD-MT-63-54; AD-602584)

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**N65-18428#** Oak Ridge National Lab., Tenn. Chemical Technology Div.

**CORROSION OF THE VOLATILITY PILOT PLANT INOR-8 HYDROFLUORINATOR AND NICKEL 201 FLUORINATOR DURING FORTY FUEL-PROCESSING RUNS WITH ZIRCONIUM-URANIUM ALLOY**

E. L. Youngblood, R. P. Milford, R. G. Nicol, and J. B. Ruch Mar. 1965 77 p refs

(Contract W-7405-ENG-26)

(ORNL-3623) OTS: \$3.00

Corrosion of the Volatility Pilot Plant process vessels was periodically determined during 40 processing runs in which uranium was recovered from both irradiated and nonirradiated zirconium and zircaloy-2-clad fuel elements. The primary reaction vessels were the hydrofluorinator, constructed of INOR-8, which was exposed to gaseous hydrogen fluoride and an NaF-LiF-ZrF<sub>4</sub> molten salt mixture at 500° to 650° C, and the fluorinator, constructed of Nickel 201 (low-carbon nickel), which was exposed to fluorine and molten salt at about 500° C. Corrosion in the INOR-8 hydrofluorinator occurred primarily by bulk-metal loss. The maximum corrosion rate of 0.14 mil/hr of HF exposure (38 mils/month of molten salt) occurred in the replacement bottom. No extensive corrosion was observed. The Nickel 201 fluorinator had significant bulk-metal losses and intergranular corrosion. The maximum Nickel 201 bulk-metal loss of 0.9 mil/hr of F<sub>2</sub> exposure occurred in the lower vapor region after 14 runs.

Author

**N65-18429#** Union Carbide Corp., Oak Ridge, Tenn. Nuclear Div.

**CHEMICAL COOLANTS FOR MACHINING URANIUM IN THE PRESENCE OF TRACE AMOUNTS OF CHLORIDE**

T. P. Sprague, J. M. Googin, and L. R. Phillips 14 Oct. 1964 51 p refs

(Contract W-7405-ENG-26)

(Y-1475) OTS: \$3.00

The presence of trace amounts of chloride was found to cause severe corrosion pitting of uranium during machining operations. A dibasic sodium phosphate solution will increase the chloride tolerance approximately 10 times over a sodium nitrite-triethanolamine-type coolant. In the phosphate coolant, sodium caprylate is required to retard corrosion of cast iron in the machine tools and benzotriazole to eliminate corrosion of the copper alloys in the coolant circulation system and bearings. Results indicate that bacterial protection is also required for routine use.

Author

**N65-18457#** Allis-Chalmers Mfg. Co., Milwaukee, Wis. Atomic Energy Div.

**PATHFINDER ATOMIC POWER PLANT CORROSION-EROSION TESTING OF STAINLESS STEEL IN OXYGENATED SATURATED STEAM**

C. R. Bergen 10 Feb. 1964 22 p

(Contract AT(11-1)-589)

(ACNP-64001)

An investigation was conducted of the corrosion-erosion characteristics of various stainless steels in dynamic saturated and superheated steam containing oxygen and moisture. The steels studied included types 304, 304L, 316, and 316L. All the alloys suffered some intergranular attack in wet oxygenated steam, and this intergranular attack increased with moisture content in the steam and carbon content in the alloy. Erosion was found for the high-carbon 304 but not for the others.

Author

**N65-18674#** Aberdeen Proving Ground, Md. Army Coating and Chemical Lab.

**A STUDY OF VARIOUS INHIBITORS FOR PREVENTION OF GALVANIC CORROSION Final Report**

W. H. Deaver 4 Jan. 1965 9 p ref

(CCL-175; AD-610136)

Various types of corrosion inhibitors and metallic salts were evaluated to determine their ability to prevent or retard galvanic corrosion of magnesium-steel assemblies. Screening tests showed sodium mercaptobenzothiazole (NaMBT) to be the most effective for prevention of galvanic corrosion on specimens immersed in a 3% salt solution. An attempt was then made to utilize NaMBT in a pretreatment for magnesium-steel couples. A procedure was developed for anodically depositing a coating from a NaMBT bath; however, the coating produced failed to provide the desired corrosion resistance.

Author

**N65-18737** Joint Publications Research Service, Washington, D. C.

**INFLUENCE OF RARE EARTH METALS AND THEIR OXIDES ON THE PLASTICITY AND ANTICORROSION PROPERTIES OF STAINLESS STEELS**

Ye. M. Savitskiy, V. F. Popov, N. V. Keys, and V. N. Lyubimov In its Probl. of the Theory and Use of Rare Earth Metals 23 Feb. 1965 p 286-291 refs (See N65-18701 09-17) CFSTI \$7.00

In case of aftercharging of REM in stainless steels in amounts of 0.05%-0.18% or of oxides of REM in amounts of 0.08%-0.12%, the technological properties of the steels are sharply improved: the surface of the ingot of steels with an addition of REM is improved on account of better fluidity, the deformability of the steels is improved, the rough cracks along the angles and edges of the blanks are eliminated, and expenditures for their cleaning during reductions are reduced by 30%-40%. The macrostructure and anticorrosion properties are improved to a considerable degree on account of purification of the grain boundaries. In the case of additions of REM and REM oxides, the strength and plasticity increase, and the anisotropy of the chemical properties of the steel is reduced. In the case of additions of REM or REM oxides, the number of twists of samples of stainless steels before breaking at 1200°

increases from 10 to 24 and from 13 to 23 revolutions, respectively

Author

**N65-18869#** Rock Island Arsenal Lab., Ill.

**ALUMINUM COMPLEX SOAPS AS THICKENERS FOR MULTI-PURPOSE GREASE**

Max T. Fisher 21 Dec 1964 22 p refs

(RIA-64-3160; AD-610560) CFSTI \$0.75

The reaction of aluminum isopropylate with mixtures of fatty acids and other organic acids in a mutual solvent is the preferred method of forming complex soaps. Of the 17 different lower molecular weight organic acids complexed with an aluminum soap, an aluminum benzoate-soap complex showed the best thickening efficiency and highest dropping point. The effects of benzoate to soap ratios, preformed complex vs in situ preparations, solvent effects on in situ preparations and additive, thickener concentration and dispersion effects were evaluated on aluminum benzoate-soap complex greases made with 74 SUS at 100° F oil

Author

**N65-19022#** General Electric Co., Evendale, Ohio Advanced Engine and Technology Dept

**INFLUENCE OF STRESS CORROSION ON STRENGTH OF GLASS FIBERS**

D. L. Hollinger, W. G. Kanetzky, and H. T. Plant 30 Nov. 1964 21 p refs

(Contract Nonr-4486(00)(X))

(BMPR-4, AD-609985)

Static fatigue tests at liquid nitrogen temperature were completed on virgin E-glass single filaments. In these tests, fibers approximately 0.0005-inch diam were dead-loaded in tension while at -196° C and maintained at that temperature for at least  $1.7 \times 10^5$  seconds. Loads were varied within the high stress region from 400 000 to 650 000 psi. No static fatigue failures were observed under these conditions, even though the stress range was high enough to cause immediate failure of some fibers upon load application. This is in distinct contrast to the behavior observed at room temperature in normal humidity where delayed failures occurred over several decades of time with stress level ranging from 200 000 to 400 000 psi.

Author

**N65-19037#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SYNTHESIS OF ORGANIC COMPOUNDS AS ADMIXTURES TO LUBRICATING OILS**

A. M. Kuliyeu 21 Jan. 1965 7 p. Transl. into ENGLISH from Vestn. Akad. Nauk SSR (Moscow), no. 7, 1962 p 51-53

(FTD-TT-64-880/1; AD-611076)

Compounds used as antifreeze, detergent, antiscald, and antioxidant additives to lubricating oils are discussed. The synthesis of condensation products of alkylphenols and urea with formaldehyde in an acid medium is presented. Condensation products, derived from alkylphenol and a tertiary carbon atom base, appear to be highly effective antioxidizing admixtures. Antioxidizing admixtures were also obtained from the reaction of ammonia and furfural. An addition of 0.01% to oil was found to increase stability to oxidation.

E. E. B.

**N65-19161#** Army Electronics Labs., Fort Monmouth, N. J. Power Sources Div.

**A STUDY OF FACTORS AFFECTING THE CORROSION RATE OF MAGNESIUM IN VARIOUS ELECTROLYTES UNDER STATIC CONDITIONS**

Carl A. Nordell Aug. 1964 17 p

(ECOM-2517; AD-609988)

The corrosion rates of magnesium and magnesium alloys in magnesium salt solutions of chloride, bromide, and perchlorate were studied by measuring the gaseous reaction product as a function of time. Reliable apparatus was developed to accurately determine the volumes of gas generated. Protective films were applied to the surface of the magnesium metal to suppress excessive chemical reactivity at the metal-electrolyte interface, thereby reducing static corrosion rates. Cramolin,

one of the films tested, reduced the gas evolution of an AZ21 Mg-2N MgBr<sub>2</sub> system from 400 cc/800 hr to 0.1 cc/800 hr

Author

**N65-19191** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INVESTIGATION OF THE THERMAL STABILITY AND CORROSIVENESS OF SULFUROUS FUELS AT TEMPERATURES ABOVE 100° C**

Ye. R. Tereshchenko and M. Ye. Tararyshkin *In its Chem. of Sulphur Org. Compds. Contained in Petrol. and Petrol. Prod.* 12 Jan. 1965 p 32-41 refs (See N65-19188 09-06)

The corrosiveness of small concentrations of sulfur containing compounds in petroleum fuels was studied at a temperature of 150° C under static conditions in a bomb, and under dynamic conditions in apparatus simulating the operation of a fuel filter of a motor. It was observed that insoluble deposits were formed above 100° C with sedimentation in the 150° to 200° C temperature interval. These products were mainly from the oxidation of sulfur, nitrogen, and oxygen organic compounds present in the fuel. Deposits were found to decrease by a factor of 2 or 3 and corrosiveness by a factor of 10 by the hydropurification of the fuel.

E. E. B.

**N65-19200#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ELECTRIC RESISTANCE TENSOMETER**

B. A. Glagovskiy, B. M. Rakhman, and U. M. Zubkov 28 Jan. 1965 5 p. Transl. into ENGLISH from the Russian Patent no. 153138 (Appl. no. 668220/25), 27 May 1960 p 1-2 (FTD-TT-64-872/1+2; AD-611051)

To expand the boundaries of measurement to the plastic range, the electric resistance tensometer was made from 0.05-mm-thick titanium-aluminum foil, containing 3% to 5% aluminum. The anticorrosion stability of the foil and its non-magnetic character allow use in caustic media and in electric and magnetic fields.

E. P. V.

**N65-19234** Bureau of Naval Weapons, Washington, D. C. **CORROSION PROTECTION OF HIGH-STRENGTH STEELS** S. Goldberg *In Battelle Mem. Inst. Probl. in the Load-Carrying Appl. of High-Strength Steels* [1964] p.78-90 refs (See N65-19226 09-17)

Stress-corrosion cracking, hydrogen embrittlement, and corrosion fatigue are considerations in serviceable corrosion protective systems. The environmental conditions are -65° F to approximately 1000° F in marine environments of the spray type with intermittent bold exposure. Although 12% type chromium steels have been widely used without protective coatings, these materials require protection for many applications. Higher chromium-content materials, although not requiring corrosion protection when used alone, require coatings where they may contact other materials or are mechanically joined with themselves. Although successful protective schemes are being used, substantive advances are needed to simplify application and maintenance. Also required are nondestructive test methods to evaluate corrosion damage which may occur.

Author

**N65-19235** Naval Research Lab., Washington, D. C. **STRESS-CORROSION CRACKING AND CORROSION FATIGUE OF HIGH-STRENGTH STEELS**

B. F. Brown *In Battelle Mem. Inst. Probl. in the Load-Carrying Appl. of High-Strength Steels* [1964] p 91-102 refs (See N65-19226 09-17)

Indications from present test methods are that many heat-treated steels are susceptible to stress-corrosion cracking at strength levels as low as 150-175 ksi yield strength in reasonable environments, and that the susceptibility increases with increasing yield strength. In approximately the same strength range, these steels also begin to exhibit susceptibility to hydrogen embrittlement, so that cathodic protection against stress-corrosion cracking cannot be used in seawater, and inorganic zinc coatings are unsuitable. A new requirement is thus imposed upon coatings for at least some of these steels; i.e., the

coatings must be more than corrosion barriers, they must be vapor barriers as well. Author

**N65-19236** Gt. Brit. Ministry of Aviation, London  
**PROTECTION AGAINST CORROSION, HYDROGEN EM-BRITTLEMENT**

H. G. Cole / In Battelle Mem. Inst. Probl. in the Load-Carrying Appl. of High-Strength Steels [1964] p 103-104 (See N65-19226 09-17)

The problem of hydrogen embrittlement, theories for the movement of hydrogen through steel, and the way in which it reduces the cohesive strength of the steel are discussed. The value of cleanness and of low sulfur and phosphorus content, not only for improved mechanical properties, but also for raising the threshold hydrogen content below which embrittlement does not occur is emphasized. Cleaning processes, protective coatings, and stress corrosion are included. Cadmium plating plus paint is considered the best protective for steel, although some hold the view that phosphate treatment plus paint is as good or even better. E.E.B.

**N65-19255#** Naval Research Lab., Washington, D. C. Chemistry Div.

**CORROSION OF METALS IN TROPICAL ENVIRONMENTS. PART G: ALUMINUM AND MAGNESIUM**

C. R. Southwell, C. W. Hummer, Jr., and A. L. Alexander 1 Dec. 1964 18 p refs

(NRL-6105; AD-609618) CFSTI: \$0.50

The corrosion resistance of 3 alloys of aluminum and 2 alloys of magnesium was studied following exposure up to 16 years in 5 natural tropical environments. These include sea water immersion, fresh water immersion, and exposure to tidal sea water, a tropical marine atmosphere, and a tropical inland atmosphere. Aluminum 1100, aluminum alloy 6061-T, and magnesium alloy AZ31X were exposed to each environment. In addition, Alclad aluminum 2024-T and magnesium alloy AZ61X were exposed to the two tropical atmospheres. Weight loss, pitting, and change in tensile properties were measured to show the extent of corrosion for each of these materials. Aluminum alloys demonstrate extremely high resistance to each environment, with the exception of tropical fresh water, in which case serious pitting occurred. Alloy 6061-T demonstrated some superiority in all environments to aluminum 1100. Author

**N65-19419#** Rock Island Arsenal Lab., Ill.

**COMPARISON OF AUTOMOTIVE LUBRICATING GREASES**  
 S. Fred Calhoun, Richard Faoro, and R. L. Young 21 Dec. 1964 12 p refs

(RIA-TR-64-3578; AD-611090) CFSTI: \$0.50

Six commercial automotive greases were evaluated along with one qualified MIL-G-10924B grease. The tests were (1) worked penetration, (2) four-ball wear and extreme pressure, (3) roll stability, (4) water washout, (5) water resistance, and (6) rust prevention. Results indicate the MIL-G-10924B grease to be better than average in wear, extreme pressure, and roll stability, and superior in rust prevention and water resistance. Author

**N65-19446#** Aerojet-General Corp., Sacramento, Calif. Advanced Storable Engine Program Div.

**HYDROSTATIC BEARING FEASIBILITY PROGRAM Quarterly Progress Report, 1 Jul.-30 Sep. 1964**

1 Dec. 1964 67 p refs

(Contract AF 04(611)-7439)

(Rept.-7439-Q-1; AD-609628)

Work on the analysis of the applicable laminar and turbulent flow laws to externally pressurized liquid-lubricated journal bearings resulted in the formation of equations for bearing pressure distribution, load-carrying capacity, fluid film stiffness, torque, horsepower loss, and coolant temperature rise that are applicable in orifice, capillary, and constant flow compensation. Computer programs to solve the equations were

prepared for journal and thrust bearings under laminar and turbulent flow conditions. The laminar flow computer programs did not yield all required data. An analysis of large turbopump bearing requirements led to the design of journal and thrust bearings, their test plans, and performance prediction. Hydrostatic thrust bearings appear to be feasible for high-speed application, very high load-carrying capacity requirements, or where the viscosity and lubricity of the fluid are not conducive to the use of rolling contact or hydrodynamic bearings. G G

**N65-19464#** Battelle Memorial Inst., Columbus, Ohio.  
**DEVELOPMENT OF NIOBIUM ALLOYS RESISTANT TO SUPERHEATED STEAM**

Arthur A. Bauer, Warren E. Berry, John A. De Mastry, Robert D. Koester, and Frank A. Rough 11 Nov. 1964 47 p refs (Contract W-7405-ENG-92)

(BML-1700; EURAEC-1285) CFSTI: \$1.00

Niobium-base alloys containing additions of 18 to 24 a/o titanium, 12 to 18 a/o vanadium, and 9 to 12 a/o chromium were prepared by arc melting, and evaluated for corrosion resistance in the cold-worked condition. Alloys containing greater than 9 a/o chromium could not be cold rolled because of a NbCr<sub>2</sub> precipitate in the grain boundaries. The niobium-21 a/o titanium-12 a/o vanadium-9 a/o chromium alloy was found to have excellent corrosion resistance to attack by 540° C deoxygenated steam, having a total weight gain of 465 mg per dm<sup>2</sup> for 10000 hr of exposure. The resistance to steam attack at 650° and 705° C appears to be adequate to withstand reactor temperature transients. There was no evidence of stress corrosion in 540° C steam or in steam to which chloride ions had been added. Loop tests indicated that the niobium-21 a/o titanium-12 a/o vanadium-9 a/o chromium alloy does not have satisfactory corrosion resistance to BWR superheater steam (20-ppm oxygen and 2.5-ppm hydrogen) at 566° C. The 540° C short-time tensile properties were excellent, the alloy processing a yield strength of 150000 psi and an ultimate tensile strength of 170000 psi. Recrystallization occurs in 1 hr at 1150° ± 10° C. Author

**N65-19465#** Illinois Univ., Urbana. Coll. of Engineering  
**THE EFFECTS OF 60-CYCLE ALTERNATING CURRENTS ON THE CORROSION OF STEELS AND OTHER METALS BURIED IN SOILS** Engineering Experiment Station Bulletin 470

Walter H. Bruckner Nov. 1964 64 p refs. Available from Illinois Univ.: \$1.50

In laboratory-operated cells which simulated field conditions of metal buried in soil, ac was found effective in accelerating the soil corrosion of all metals tested, including ferrous and nonferrous alloys. Corrosion due to ac resulted from thermal and electrical effects. The electrical effects may be contributed by ac only when dc is blocked from the circuit. No consistent relationship could be found between ac and the dc component in cells with steel electrodes. In addition, a dc component was found in cells with apparently identical steel electrodes and environment. The presence of ac in an electrical circuit composed of different metals buried in soil increased the dc current in the galvanic cell, and increased the corrosion rate normally expected for the anode of such a cell. Author

**N65-19527#** ARO, Inc., Arnold Air Force Station, Tenn.  
**TESTS OF DRY COMPOSITE LUBRICATED BEARINGS FOR USE IN AN AEROSPACE ENVIRONMENTAL CHAMBER, MAY 1-JUNE 16, 1964**

T. L. Ridings Arnold Eng. Develop. Center, Mar. 1965 45 p refs

(Contract AF 40(600)-1000)

(AEDC-TR-65-35; AD-458414)

This report contains the results of a test program to determine the operational characteristics of dry composite lubricated bearings. Two different bearing types were tested:

\* tapered roller bearings and ball bearings. Four dry composite lubricants and two low vapor pressure greases were tested. Results indicate that the dry composite lubricants were more successful when used with ball bearings than when used with tapered roller bearings. All four composite lubricants provided low system torques (40 to 60 lb in.) under heavy loads (3000 lb/bearings) for the scheduled 100 hours. Best results were obtained using Cu and PTFE and WSe<sub>2</sub> and a silver alloy + PTFE + WSe<sub>2</sub>. One low vapor pressure grease was successful as a lubricant at room temperature but migrated at temperatures above room temperature. The other low vapor pressure grease was successful at temperatures up to 140° F with no migration. Author

**N65-19592#** Joint Publications Research Service, Washington, D. C.

**STEELS IN POWER MACHINERY Selected Articles**

16 Mar. 1965 26 p refs Transl. into ENGLISH from Energomashinost. (Moscow), no. 10, Oct. 1964 p 26-29, 29-30, 30-32

(JPRS-29139, TT 65 30520) CFSTI: \$1.00

The first article discusses the apparent discrepancy between laboratory data on the stability of stainless and carbon steels and their actual resistance to cavitation erosion under operating conditions in hydroelectric turbines. Mechanical and impact-corrosional aspects of steel disintegration are considered in demonstrating that differences in cavitation intensity account for variations in the stability data. The second article discusses the effects of annealing variables on the strength and durability of steel pins with rolled threads. The third article discusses the ways in which an oxide layer influences the kinetic and diffusion reactions of gas corrosion of steel, particularly in cases where the oxide layer is continually being chipped away. M. P. G.

**N65-19660#** Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.

**CORROSION OF TYPE 316 STAINLESS STEEL IN NaK SERVICE—A LITERATURE SURVEY**

C. A. Zimmerman Feb. 1965 21 p refs

(Contract AT(10-1)-205)

(IDO-14651) CFSTI: \$1.00

A literature survey of work on corrosion of stainless steel, especially Type 316, by NaK and sodium was made. In general, the Type 316 and Type 304 stainless steels should give good performance with NaK. The mechanisms which can lead to failure are attack by impurities at temperatures under 550° C, and carbide precipitation, sigma formation, and mass transfer at higher temperatures. Author

**N65-19727#** General Electric Co., Cincinnati, Ohio. Materials Development Lab.

**THE DEVELOPMENT OF METHODS FOR THE ULTRASONIC INSPECTION OF BEARINGS Final Engineering Report, Mar. 1963-Sep. 1964**

E. N. Bamberger and J. D. Marble 20 Oct. 1964 93 p refs

(Contract NOW-63-0383-d)

(AD-454013)

A program was conducted to develop and demonstrate feasibility of an ultrasonic inspection technique for anti-friction bearings. The purpose of this type of nondestructive inspection is to increase the reliability of bearings by the elimination of those parts subject to premature failure. The special ultrasonic inspection technique coded MC<sub>3</sub> is particularly suited for bearing inspection, due to the ability to control its depth of scan, thereby restricting the inspected region. Using the MC<sub>3</sub> technique, the inner and outer raceways of 100 ball bearings were inspected prior to assembly. The inspection data were analyzed and the bearings ranked in order of probability of failure. Following testing, a reinspection was performed

on a number of long-life, unfailed bearings to determine whether the MC<sub>3</sub> inspection could also detect incipient sub-surface failures. The MC<sub>3</sub> inspection is capable of sorting out those bearings likely to fail in the early portion of life, although not yet on a completely reliable basis. Until the reliability can be more absolute, the MC<sub>3</sub> method cannot be recommended for immediate application as a quality control measure. Author

**N65-19849\*#** General Electric Co., Cincinnati, Ohio. Missile and Space Div.

**MATERIALS FOR POTASSIUM LUBRICATED JOURNAL BEARINGS Quarterly Progress Report No. 6, Jul. 22-Oct. 22, 1964**

R. G. Frank, ed. [1964] 74 p refs

(Contract NAS3-2534)

(NASA-CR-54264) CFSTI: HC \$3.00/MF \$0.75

Twenty Cb-12r alloy capsule assemblies were filled with purified potassium and tested isothermally for 1000 hours at 800°, 1200° F, and 1600° F in a vacuum of 10<sup>-8</sup> to 10<sup>-9</sup> torr. Chemical analyses, by the mercury amalgamation method, of samples of the potassium taken at the same time that the capsules were filled, indicated the potassium contained less than 50 ppm oxygen. Each of the three sets of six capsules contained test specimens of K601, TiC, 10%Cb+TiC, 5%W+TiC, Grade 7178, and Star J materials. Two additional capsules, tested at 1600° F, contained specimens of 10%-Mo+TiC and TiB<sub>2</sub>, respectively. The chamber pressure at the end of the test was 1 × 10<sup>-9</sup> torr. To evaluate dimensional stability, duplicate specimens of 10 of the 14 candidate materials were tested for 1000 hours at 1200° and 1600° F in vacuum. The chamber pressure at the conclusion of the test was 1.3 × 10<sup>-9</sup> torr. Of the 10 materials evaluated, the Zircoa 1027 was the only material to show a significant change in dimensions, i.e., approximately +0.4%, as a result of the 1000-hour exposure at 1600° F. Author

**N65-19893\*** SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**BEARING LUBRICANT ENDURANCE CHARACTERISTICS AT HIGH SPEEDS AND HIGH TEMPERATURES Progress Report No. 9, Oct. 1-Dec. 31, 1964**

C. J. Wachendorfer [1964] 43 p refs

(Contract NASw-492)

(NASA-CR-57445; AL65T002) CFSTI: HC \$2.00/MF \$0.50

Testing has continued with nine consumable electrode vacuum melted steel angular-contact ball bearings and three high-temperature lubricants, viz. a highly viscous ester base oil, a six-ring polyphenyl ether, and a viscous hydrocarbon, at speeds up to 45 000 rpm, mean temperatures up to 680° F and under 365 lbs thrust load. Checkout tests were conducted to determine the operating temperature of the rig and bearings when heated by internal heat generation only, at 45 000 rpm and to arrive at a suitable arrangement for external cooling. Author

**N65-19971#** General Electric Co., Schenectady, N. Y. Advanced Technology Labs.

**LUBRICATION OF HEAVILY LOADED, LOW VELOCITY BEARINGS AND GEARS OPERATING IN AEROSPACE ENVIRONMENTAL FACILITIES**

Ralph E. Lee, Jr. Arnold AF Sta., Tenn., Arnold Eng. Develop. Center, Jan. 1965 212 p refs

(Contract AF 40(600)-1013)

(AEDC-TR-65-19; AD-456355)

This report presents the results of a balanced study of bearings and gears for heavily loaded, low velocity space simulator applications, integrated with a research effort directed toward the development of materials, lubricants, application processes, and evaluation and testing techniques. Solid film

lubricants consisting of molybdenum disulfide and graphite with silicate and epoxy-type binders, and thin-film platings of gold and silver, were among the better performers. Molybdenum disulfide-glass, and graphite aluminum phosphate were among the more successful solid film lubricants developed. Apiezon L, a low vapor pressure petroleum distillate exhibited good performance characteristics. Lubricated cylindrical, spherical, ball, and tapered rolling element bearings of 30-, 50-, and 100-mm-bore sizes were tested in this effort. The gears tested were helical. Author

**N65-20203** Joint Publications Research Service, Washington, D. C.

**INTERACTION OF SOLDER WITH THE MATERIAL BEING SOLDERED. 2: DISSOLUTION OF BASE METAL DURING SOLDERING**

N. F. Lashko and S. V. Lashko *In its Studies in the Brazing and Soldering of Metal Alloys* 2 Mar. 1965 p 9-19 refs Transl. into ENGLISH from Avtomat. Svarka (Kiev), 1963 p 30-35 (See N65-20201 10-15) CFSTI: \$2.00

A study was made of the dissolution of pure metals in more readily fusible liquid metals (solders) under the conditions approximating those of capillary soldering and soldering in a bath. Rate of dissolution with rising temperature depends on the amount of solder and structure of the alloy that is formed in the soldered seam and the zone of diffused interaction. Formation of interlayers of incongruent chemical compounds at the contact of liquid solder with the metal being soldered decreases the rate of its dissolution near the peritectic temperature. Ways of lowering the rate of dissolution of the metal being soldered in the liquid solders are considered. Author

**N65-20483\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**SALT-STRESS-CORROSION CRACKING OF RESIDUALLY STRESSED Ti-8Al-1Mo-1V BRAKE-FORMED SHEET AT 550°F (561°K)**

Richard A. Pride and John M. Woodward Washington, NASA, Apr. 1965 27 p refs (NASA-TM-X-1082) CFSTI: HC \$1.00/MF \$0.50

An experimental investigation of salt-stress-corrosion cracking with residual stresses was conducted with one of the supersonic-transport candidate materials, Ti-8Al-1Mo-1V. Specimens with right-angle bends were brake formed from sheet material to produce residual stresses, coated with sodium chloride, and exposed at 550°F (561°K). After various exposure times, some of the specimens were given a reverse-bend test to determine the extent of cracking based on bending deflection. Other specimens were examined metallurgically. Salt-stress-corrosion cracks began to appear in less than 20 hours, and the effects were at least as severe as the effects produced by load-induced tensile stresses. Several approaches were examined for alleviating the corrosion cracking, and, of these, shot peening and nickel plating appear promising enough to warrant further investigation. Author

**N65-20570#** National Research Council of Canada, Ottawa (Ontario).

**QUARTERLY BULLETIN OF THE DIVISION OF MECHANICAL ENGINEERING AND THE NATIONAL AERONAUTICAL ESTABLISHMENT, 1 JULY TO 30 SEPTEMBER 1964 [1964] 96 p refs (DME/NAE-1964(3))**

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2. PHOTOGRAMMETRIC CHECKING OF WIND TUNNEL MODELS A. J. Bowker p 15-43 (See N65-20572 10-15)

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**N65-20571** National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab

**LOW TEMPERATURE CHARACTERISTICS OF MULTIPURPOSE GEAR OILS**

R. B. Whyte *In its Quart. Bull. of the Div. of Mech. Eng. and the Natl. Aeron. Estab.* 1 Jul to 30 Sep 1964 [1964] p 1-14 refs (See N65-20570 10-15)

The performance of four multipurpose gear oils in laboratory bench tests, in differential assemblies in the cold room, and in the same vehicle differential is reported. It was concluded: (1) At the low ambient temperatures at which 75 grade oils are used, the chemical activity of the E. P. additives is too low to prevent surface damage to the gear teeth under severe conditions. An increase in additive content of 25% over that used in the higher grades is sufficient to give satisfactory protection. (2) Excellent correlation was obtained between channel points and the temperature at which the oil begins to seriously affect the torque required to turn a differential assembly. (3) There was no evidence that prolonged storage at low temperatures results in torque requirements greater than storage overnight. (4) The original Army recommendations for changing from 90 to 75 grade lubricants in rear axles at about +32°F ambient did not agree with either these findings or with commercial practice. Change should be made at 0° to -10°F. E E B

**N65-20708#** Oak Ridge National Lab., Tenn. **EVALUATION OF HASTELLOY F AND OTHER CORROSION-RESISTANT STRUCTURAL MATERIALS FOR A CONTINUOUS CENTRIFUGE IN A MULTIPURPOSE FUEL-RECOVERY PLANT**

W. E. Clark, L. Rice, and D. N. Hess Apr. 1965 16 p refs (Contract W-7405-ENG-26) (ORNL-3787) CFSTI: \$1.00

Hastelloy F was found suitable as a material of construction for a centrifuge to be used for clarifying solutions generated in various nuclear head-end processing schemes. The maximum corrosion rate was  $\leq 0.7$  mil/month in all solutions tested. Test temperature was 35°C. Candidate materials besides Hastelloy F included Carpenter 20SCb stainless steel, Hastelloy C, titanium-45A, and a vacuum-melted, low-carbon variation of Ni-0-nel. Hastelloy F was the only one of these materials which was satisfactorily resistant to all of the test solutions. Author

**N65-20710#** Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.

**STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEEL Status Report, September 1, 1964**

Mc Intyre R. Louthan, Jr. Feb. 1965 22 p refs (Contract AT(07-2)-1) (DP-957) CFSTI: \$1.00

Stress corrosion cracking of austenitic stainless steel is being investigated to develop a fundamental understanding of the phenomenon. This report presents the status of studies relating specimen microstructure and dislocation substructure to the susceptibility to stress corrosion cracking. Anodic dissolution plays a major role in the nucleation and propagation of stress-corrosion cracks. The susceptibilities of different heats of the same type of steel to cracking are quite different, and these differences are not attributable to differences in the composition of major alloying elements, material hardness, or dislocation substructure. It is also shown that the relative rate of preferential attack at dislocation arrays and stacking faults in thin foils of type 304 stainless steel exposed to dilute NaCl solutions increased with increasing temperature and was more rapid in heats of steel which were most susceptible to cracking in bulk tests. Author



**N65-20807\*# Electro-Optical Systems, Inc., Pasadena, Calif.  
HYDROGEN-OXYGEN ELECTROLYTIC REGENERATIVE  
FUEL CELLS**

Harvey Frank 10 Dec. 1963 9 p

(Contract NAS3-2781)

(NASA-CR-57665; EOS-4110-M-4) CFSTI: HC \$1.00/MF \$0.50

Design of the fuel cell assembly was completed. Also, the cycle controller design was established. A few modifications of the first fuel cell design were made to improve reliability and simplify fabrication. The first such modification consisted of increasing the diameter of the separators to provide more sealing area for the Teflon gaskets. A second change consisted of increasing the thickness of the separators to simplify the machining of the inlet radial holes which serve as inlet gas ports. Five oxygen electrodes were completed. A sample of butyl rubber from which the balance diaphragm is to be made was held at 100°C for 5 days under 100 psig of oxygen. No apparent change in surface properties or elasticity was noted. Samples of magnesium and aluminum were subjected to the same tests with no apparent change in the metal surfaces. Kanigen plated nickel was tested under electrolysis. No signs of penetration into the substrate material were noted. Single cell data were also included. E.E.B.

**N65-21054# Ampex Corp., Redwood City, Calif.  
DERIVATION OF GOVERNING EQUATIONS FOR SELF-  
ACTING FOIL BEARINGS**

Edward J. Barlow Feb. 1965 29 p refs

(Contract Nonr-3815(00)(X))

(RR-65-1; AD-612720)

Contained is the derivation of the equations for the self-acting foil bearing. These equations include the effects of bending stiffness of the tape and of compressibility of the lubricant. They are nonlinear, and the boundary conditions are divided equally between the two ends of the tape. These complications even make obtaining numerical solutions difficult. Linearized solutions are derived for large wrap angles neglecting the bending stiffness of the tape. Author

**N65-21108# Air Force Systems Command, Wright-Patterson  
AFB, Ohio Foreign Technology Div.  
HIGH TEMPERATURE ARRANGEMENT FOR TESTING  
LONG LASTING STRENGTH AND CORROSION STABIL-  
ITY OF STRUCTURAL MATERIALS IN LIQUID SODIUM**

V. I. Nikitin 14 Jan. 1965 11 p refs Transl. into ENGLISH from Teploenerg. (Moscow), no. 5, 1963 p 80-83 (FTD-TT-64-704/1+2; AD-610299)

In this report are described structural features of a lab arrangement for testing corrosion resistance and strength of structural materials in a sodium stream at a temperature of up to 1000°C. Given are results of brief corrosion testing of nickel base alloys and chromium nickel austenitic steel at 1000°C. Author

**N65-21161\*# Thompson Ramo Woolridge, Inc., Cleveland,  
Ohio  
OPERATION OF A FORCED CIRCULATION, CROLOY 9 M,  
MERCURY LOOP TO STUDY CORROSION PRODUCT SEP-  
ARATION TECHNIQUES**

D. B. Cooper and E. J. Vargo Washington, NASA, Apr. 1965 102 p refs

(Contract NAS3-2538)

(NASA-CR-217) CFSTI: HC \$4.00/MF \$0.75

A Croloy 9M, forced circulation, mercury loop was designed and operated for a total of 2918 hours at an average boiling temperature of 1074°F. Corrosion product separators were included in both the vapor and liquid sections of the system and were evaluated for their effectiveness in reducing problems associated with mass transfer in mercury systems. Corrosion data for this system were found to agree favorably

with previously reported data for Croloy 9M. The separators in the vapor portion of the system removed 54.3% of the corroded metals found in the system, while the separator in the liquid region removed 24.7% of the corroded metals. Carbon diffusion was noted in the Type 316 SS-Croloy 9M composite tubing at temperatures above 1200°F. The diffusion of carbon from the Croloy 9M to the Type 316 SS resulted in grain coarsening of the Croloy 9M and a profusion of carbides in the Type 316 SS. The composite tubing also exhibited excessive creep after 2918 hours at 1405 ± 10°F, apparently a result of metallurgical changes in the Type 316 SS. Deposition and corrosive and/or erosive attack were observed, after 448 hours of loop operation, in a Croloy 9M throttling valve located at the superheater outlet. Author

**N65-21177# Rock Island Arsenal Lab., Ill.  
INVESTIGATION OF VOLATILE CORROSION INHIBITOR  
ADDITIVES FOR STANDARD OPERATING OILS TO IM-  
PROVE THEIR PRESERVATIVE CHARACTERISTICS**

Joseph H. Weinberg and Gerald Pributsky 21 Dec. 1964 24 p (RIA-64-3577; AD-612732)

The work demonstrated the feasibility of using carefully selected concentrates to improve the preservative properties of an operating lubricant. However, unpredictable compatibility problems may prevent application of this process. Of three concentrates found that would provide vapor phase protection comparable to that of Specification MIL-L-46002 VCI oil, and exhibit only slight sedimentation in compatibility tests with operating lubricants, only one had the supply and logistics properties desirable. Concentrates in liquid form were revealed best suited because solubility problems were encountered with the powdered form of concentrate. The type of diluent which is part of the concentrate can also produce detrimental effects on a product when added to an operating oil as evidenced by drastic changes in viscosity, pour point and flash point. Author

**N65-21303\*# SKF Industries, Inc., King of Prussia, Pa. Re-  
search Lab.  
BEARING LUBRICANT ENDURANCE CHARACTERIS-  
TICS AT HIGH SPEEDS AND HIGH TEMPERATURES Prog-  
ress Report No. 7, Apr. 1-Jun. 30, 1964**

C. J. Wachendorfer [1964] 33 p refs

(Contract NASw-492)

(NASA-CR-57982; AL-64T035)

Ten consumable-electrode vacuum-melted (CVM) WB-49 tool steel 7205 angular contact ball bearings were tested at 20000 rpm, 365 lbs thrust load and mean temperatures up to 610°F. Two hydrocarbon oils, Kendex bright stock 0846 and Socony XRM-109F and the ester base oil, Socony RM-139A, were used to lubricate the bearings. Also, cage designs and materials evaluation continued to aid in selecting the most desirable design which would eliminate the cage guide wear experienced in previous testing and will be utilized in bearings yet to be tested. An associated research program to select the most wear-resistant cage materials for application in high temperature bearings continued with recent testing at temperatures up to 700°F, using polyimide plastic cage specimens and two of the candidate high temperature lubricants, Monsanto OS-124 and Esso FN-3157. Author

**N65-21344\*# Materials Research Lab., Inc., Richton Park, Ill.  
ELEVATED TEMPERATURE STRESS CORROSION OF HIGH  
STRENGTH SHEET MATERIALS IN THE PRESENCE OF  
STRESS CONCENTRATORS First Interim Report**

R. L. Kirchner and E. J. Ripling Nov. 1964 98 p refs

(Contract NASr-50)

(NASA-CR-57914) CFSTI: HC \$3.00/MF \$0.75

Under laboratory creep furnace conditions, AM 350 stainless steels, Inconel W, and V-36 were unaffected by 1000-hr exposures at 650°F and 60 ksi in the presence of sea salt. Salt coated samples of the titanium alloys, Ti-6Al-4V and

Ti-8Al-1Mo-1V, however, were found susceptible to stress corrosion cracking at 650° F and 17.5 ksi under the same creep furnace exposures. The average time to failure for the latter was about 240 hr, although two specimens survived the 1000 hr while one failed after only 23 hr. At 600° F, practically no deterioration was found in the titanium alloys after 1000 hours of exposure. The severe sensitivity of titanium alloys to hot salt in laboratory tests is not consistent with its reported behavior in service. To predict whether or not titanium is safe in specific applications requires a better understanding of the mechanism of hot salt stress corrosion cracking. A tentative mechanism for hot dry salt stress corrosion is proposed.

Author

**N65-21445#** Mechanical Technology, Inc., Latham, N. Y.  
**AN EXPERIMENTAL STUDY OF FRICTION IN ELASTO-HYDRODYNAMIC LUBRICATION**

M. D. Longfield 28 Aug. 1964 26 p refs  
 (Contract Nonr-3729(00)(FBM))  
 (MTI-64TR63, AD-610134)

The main features of the apparatus were described by Orcutt. Two 1/4-inch-wide, 6-inch-diameter disks were mounted with their axes horizontal, each being driven independently through Vee-belt drives by infinitely variable-speed electric motors. The disks were made to roll or roll and slide on their peripheral surfaces while loaded together. The upper steel disk was held in a lever assembly which was supported at one end by a self-aligning pivot. Load to the disks was applied by applying dead weights to the other end of the lever arm. The lower disk, made of glass, was driven at the same or lesser speed than the steel disk. Both disks were polished on their peripheries to a surface finish of a few microinches. Provisions were available for the true alignment of the disks to provide a symmetrical distribution of load across their width. A jet of lubricant was supplied to the inlet side of the contact, and an intercooler was incorporated in the oil circuit to minimize oil supply temperature fluctuations.

Author

**N65-21626\*#** General Electric Co., Cincinnati, Ohio. Missile and Space Div.  
**POTASSIUM CORROSION TEST LOOP DEVELOPMENT**  
 Quarterly Progress Report No. 6 for the Period Ending Jan. 15, 1965

E. E. Hoffman, ed. 12 Mar. 1965 60 p refs  
 (Contract NAS3-2547)

(NASA-CR-54344) CFSTI: HC \$3.00/MF \$0.50

The development of a prototype corrosion test loop for the evaluation of refractory alloys in boiling and condensing potassium environments which simulate projected space electric power systems is considered. Loop I, a natural convection loop, was operated for 1000 hours with liquid sodium at a maximum temperature of 2260° to 2380° F to evaluate the electrical power vacuum feedthroughs, the thermocouples, the method of attaching the electrodes, the electrical resistivity characteristics of the heater segment, and the use of thermal and electrical insulation. Loop II, a single-phase sodium, forced-circulation loop to evaluate the primary loop EM pump, a flowmeter, the flow control and isolation valves, and the pressure transducers completed 2650 hours of scheduled testing. This loop operated at a pump inlet temperature of 1985° F. Residual sodium was distilled from the loop and component evaluation initiated. The prototype corrosion test loop, a two-loop Cb-12r system, was designed and partially fabricated. It will include a boiler, turbine simulator, and condenser. This facility will be used to develop and endurance test (2500 hours) the components required to achieve stable operation at the corrosion test design conditions.

R. W. H.

**N65-21714#** Battelle Memorial Inst., Columbus, Ohio.  
**PHASE, THERMODYNAMIC, OXIDATION, AND CORROSION STUDIES OF THE SYSTEM URANIUM-NITROGEN**

Josef Bugl and Arthur A. Bauer 4 Sep. 1964 42 p refs  
 (Contract W-7405-ENG-92)  
 (BMI-1692, EURAEC-1210) CFSTI: \$1.00

The pressure-temperature dependence of UN decomposition and melting, of equilibrium between the UN and U<sub>2</sub>N<sub>3</sub> phases, and of nitrogen solution in the U<sub>2</sub>N<sub>3</sub> phase was determined as well as the solubility of UN in liquid uranium. From the experimental data, thermodynamic functions for the formation of U<sub>2</sub>N<sub>3</sub> from UN and nitrogen gas and for the solution of nitrogen in U<sub>2</sub>N<sub>3</sub> were determined. For the latter, integrated thermodynamic functions for the solution of nitrogen in U<sub>2</sub>N<sub>3</sub> were calculated. The oxidation kinetics of UN in CO<sub>2</sub>, oxygen, and water-saturated air were found to obey the linear weight-gain law with activation energies ranging from 10400 to 15400 cal per mole. The oxidation product in atmospheric gas at temperatures of 300° C and greater was U<sub>3</sub>O<sub>8</sub>. UN corroded in 300° C water to form UO<sub>2</sub>, but the rate of corrosion was highly sensitive to stoichiometry and to density with cast, 100% dense, stoichiometric UN exhibiting optimum corrosion resistance as compared with nonstoichiometric UN prepared either by casting or by powder metallurgy. Corrosion rates in 100° C water, 350° C Santowax R, and 820° C NaK were low or negligible.

Author

**N65-21777\*#** Kaiser Aluminum and Chemical Corp., Spokane, Wash. Dept. of Metallurgical Research  
**INVESTIGATION OF WELDING AND FABRICABILITY OF KAISER EXPERIMENTAL ALLOY MR39A** Final Project Report, Jul. 1, 1962-Sep. 30, 1963

F. R. Baysinger 21 May 1964 178 p

(Contract NAS8-5065)

(NASA-CR-62233, MS-PR-64-12) CFSTI: HC \$5.00/MF \$1.00

The feasibility of the new Al alloys X7038 and 7039 for use in space and missile programs was investigated by (1) determination of mechanical properties at room temperature and -320° F of flat-position TIG weldments of alloys X7038-T6, X7038-T7, and 7039-T6, (2) stress corrosion tests of X7038-T6, X7038-T7, and 7039-T6 parent plate and weldments, and (3) weldability of the alloys by the MIG process in the flat position. Results showed that the best overall performance with weldments of these alloys was obtained with filler X5039 containing about 4% Mg and 3% Zn. Weldments of 7039-T6 made with this filler gave high tensile strength and excellent ductility, and were readily made under restraint with a minimum of weld cracking. The excellent properties of 7039 weldments were obtained with specimens containing nominal amounts of twinning, porosity, dross, incomplete penetration, and other defects. Detailed descriptions and data of the various tests and mechanical properties of the different alloys are included.

G. G.

**N65-22046#** Naval Air Engineering Center, Philadelphia, Pa. Aeronautical Materials Lab  
**VAPOR LUBRICATION OF HIGH SPEED BALL BEARINGS**  
 Leon Stallings 4 Jan. 1965 8 p  
 (NAEC-AML-2107, AD-457104)

The lubricant properties of reaction products resulting from the interaction of vapors generated by volatile compounds and the constituents of the metal bearing surfaces were investigated. Vapor lubrication phenomena studied were decomposition of vapor at elevated temperature yielding a liquid fraction, formation of solids produced by chemical reaction between metal and vapor, and physical adsorption of vapors on metal surfaces. Volatile compounds investigated were amine dithiocarbamates, chlorinated aromatic amines, and bromocamphor. Results of additional studies on the effect of carrier gas properties on vapor lubrication are also presented. Tables are included which show the lubricant performance properties of 14 different organic compounds using nitrogen carrier gas. Chromium alloy bearings having carbon steel retainer components served as test specimens.

S. C. W.

**N65-22059#** Aeronautical Research Labs., Melbourne (Australia) Dept of Supply  
**CORROSION OF ALUMINIUM**  
 K. F. Lorking Sep. 1964 24 p refs  
 (ARL/MET-54)

As part of the proposed system for analysis of mechanisms of corrosion processes on aluminium, a technique for correlation of oxide film thickness with electrode potential on corroding aluminium is described. Results of oxide film thickness measurements are also used to give a more complete analysis of the mechanism of the effect of the chloride ion on corrosion of aluminium. Methods based on film thickness measurements and electrochemical measurements are proposed for the rapid assessment of the corrosive power of solutions towards aluminium. A series of standard measurements of corrosion weight losses, oxide film thickness determination and electrochemical measurements on pure aluminium have been obtained.

Author

**N65-22093#** Menasco Mfg. Co., Burbank, Calif.  
**EVALUATION OF LOW EMBRITTLEMENT TITANIUM CADMIUM (DELTA) PLATING PROCESS AS PERFORMED BY THE MENASCO, BURBANK FACILITY**  
 B. Gahnberg and J. Shelby 11 Jun 1964 20 p  
 (A600)

Notched sustained load specimens of 4330M steel, heat treated to the 220 to 240-Ksi range and plated with titanium cadmium plate, withstood sustained load at a stress equal to 75% of the notched tensile strength for periods up to 700 hours, without failure. Notched 4340 steel specimens, heat treated to the 260 to 280-Ksi range and plated with titanium cadmium plate, withstood 700 hours of load without failure. Titanium cadmium plated salt-spray panels withstood more than 2600 hours of intermittent salt-spray exposure without any trace of corrosion products. Titanium cadmium (Delta) plating process shows no embrittling characteristics when applied to both 4330M at the 220 to 240-Ksi strength level, and 4340 at the 260 to 280-Ksi ultimate strength range. The corrosion resistance, as measured by salt-spray exposure, far exceeds that of any other conventional protective surface finish.

Author

**N65-22144#** Naval Research Lab., Washington, D. C. Chemistry Div.  
**SYNTHESIS, CHARACTERIZATION, AND ESTER-ESTER INTERCHANGE STUDY OF THE MIXED ESTER 2-ETHYLHEXYL BENZYL AZELATE**  
 Jacques G. O'Rear and Paul J. Sniegowski 8 Jan. 1965 12 p refs  
 (NRL-6149, AD-612092) CFSTI: \$0.50

New components are in demand for low-temperature instrument oils. To meet this demand two new esters, bis(3,4-dichlorobenzyl)beta-methyladipate and 2-ethylhexyl benzyl azelate, were synthesized and although both esters possessed the required high surface tensions (43.6 and 33.4 dynes/cm at 20°C, respectively), only the azelate had a suitable viscosity for low-temperature application. This mixed ester, 2-ethylhexyl benzyl azelate, was prepared by the esterification of the half ester, 2-ethylhexyl hydrogen azelate, with a large excess of benzyl alcohol. A study was made of the disproportionation of 2-ethylhexyl benzyl azelate into two symmetrical diesters: 2(2-ethylhexyl benzyl azelate) reversibly yields dibenzyl azelate + bis(2-ethylhexyl)azelate. The reaction rates for this ester-ester interchange were found to be too small to restrict the desired application of the mixed ester at temperatures below

Author

**N65-22149#** Naval Research Lab., Washington, D. C. Chemistry Div.  
**STABILIZATION OF SILICONE LUBRICATING FLUIDS AT 300° TO 400°C BY SOLUBLE CERIUM COMPLEXES**

H. R. Baker, J. G. O'Rear, P. J. Sniegowski, and R. E. Kagarise  
 8 Jan. 1965 23 p refs  
 (NRL-6156; AD-612064)

The Si-H bond was shown to be involved in the formation of a stable cerium-silicone inhibitor system and this discovery was applied to the development of improved methods for stabilizing silicones. The inhibitory process uses initial reactions between hydrous cerous acetylacetonate and a polymethylhydrogen silicone. These reactions proceed and terminate in aerated refluxing benzene to provide a silicone-soluble adduct. The chemistry of the hydride group was followed quantitatively and some features of structure are postulated for the adduct. The simplified inhibitory process is a two-step reaction. Stabilization is completed by aerating a mixture of the cerium adduct and a silicone oil for one hour at 270° to 280°C. There is an optimum concentration of cerium adduct for the stabilization of lightly phenylated dimethyl silicones. The same concentration achieves 100 to 500 percent improvements in the 300°C stability of dimethyl silicones and their chlorophenyl- and phenyl-substituted types; with more highly phenyl-substituted silicones, stabilization temperatures are raised to 400°C and relative improvement factors roughly parallel those observed at 300°C.

Author

**N65-22166#** SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**BEARING LUBRICANT ENDURANCE CHARACTERISTICS AT HIGH SPEEDS AND HIGH TEMPERATURES** Progress Report No. 10, Jan. 1-Mar. 31, 1965

C. J. Wachendorfer [1965] 58 p refs

(Contract NASw-492)

(NASA-CR-62341; AL-65T031) CFSTI: HC \$3.00/MF \$0.50

Longer bearing life was obtained with polyphenyl ether type lubricants than in previous tests. A modified polyphenyl ether having a -20°F pour point operated in one test at 500°F at 42 800 rpm and 365-lbs load for 58.8 million revolutions without surface stress. Also, a six-ring fluid operated in another test at 598°F for 50.3 million revolutions with only slight glazing of the inner-ring ball track. Two of four tests with the five-ring lubricant in an air environment survived for appreciable lives, which may reflect an improved boundary lubricating characteristic of this oxidation-resistant fluid. A single test was performed at 580 lb load with M-1 bearings and an ester-base lubricant at 500°F to establish the limiting load for this bearing-lubricant combination. One bearing smeared after 115.3 million revolutions at 500°F, while the other bearing operated for the same life at 484°F without surface stress. Results of endurance testing at 42 800 rpm, completed on three groups of statistically similar 7205 bearings, are also reported.

E.E.B.

**N65-22212#** RAND Corp., Santa Monica, Calif.  
**CORROSION AS A PROBLEM TO THE AIR FORCE**

Robert C. Drebelbis (USAF) Mar. 1965 7 p Presented at the AF Logistics Command Commanders' Conf., San Antonio, 12 Mar. 1965

(P-3080; AD-611877)

The following recommendations are made to the Air Force to insure an effective corrosion control program: (1) recognition of corrosion as a major problem at "top side" in DOD and USAF, (2) trained engineers to insure compliance with existing design, procurement, production, modification and maintenance directives at all levels, (3) eliminate the small economics in procurement and production that later develop into costly maintenance and modification requirements, (4) provide for and enforce proper cleaning and protection of weapon systems and ground support equipment in the field.

TAB

**N65-22375#** ARO Inc., Arnold Air Force Station, Tenn.  
**TESTS OF DRY COMPOSITE LUBRICATED GEARS FOR USE IN AN AEROSPACE ENVIRONMENTAL CHAMBER**  
 T. L. Ridings. Arnold Eng. Develop. Center, Mar. 1965. 55 p refs  
 (Contract AF 40(600)-1000)  
 (AEDC-TR-65-45; AD-460502)

The results are reported of a test program set up to determine the operational characteristics of dry composite lubricated gears. Two diametral pitch sizes, 7 and 12, and two gear materials, nitralloy steel and nodular iron, were tested. Three dry composite lubricants and one low vapor pressure grease were tested. All three dry composite lubricants provided adequate lubrication for periods of up to 300 hr at 100 rpm with very little wear of either load gears or lubricating idlers. The MoS<sub>2</sub>-fortified, grease-lubricated gears failed after 40 hr of operation.

Author

**N65-22385#** Naval Ordnance Test Station, China Lake, Calif.  
**THE EFFECT OF ADDITIVES ON FLUID FRICTION**  
 J. W. Hoyt and A. G. Fabula. Dec. 1964. 34 p refs  
 (NAVWEPS-8636; NOTS-TP-3670; AD-612056)

A brief review is given of the literature on turbulent flow of high-polymer solutions. Laboratory experiments using rotating disks and turbulent pipe flow have led to generalizations as to characteristics of friction-reducing high polymers. Linear, high-molecular-weight, soluble polymers are shown to be most effective. The maximum drag reduction achievable by polymer addition appears to be a function of the Reynolds number of the flow.

TAB

**N65-22403#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**LUBRICATION FOR THE HOT ROLLING OF STEEL PIPE**  
 P. I. Chuyko, M. S. Goncharevskiy, and Ye. I. Tsyganck. 18 Mar. 1965. 4 p. Transl. into ENGLISH from Russian Patent no. 161857 (Appl. no. 834359/23-4), 3 May 1963  
 (FTD-TT-64-1086/1; AD-613159)

A lubricant for the hot rolling of steel pipe consisting of an aqueous solution of graphite and Chile saltpeter with a calcium hydroxide additive for improving the quality and eliminating manual operation is described. The composition of the proposed lubricant and procedures used in its preparation are discussed. The lubricant can be used on pipes ranging in temperature between 300° to 500° C and can be applied by using a crane to dip batches.

S. C. W.

**N65-22421#** General Dynamics/Fort Worth, Tex. Nuclear Aerospace Research Facility.  
**EFFECTS OF REACTOR RADIATION ON FIVE HIGH-TEMPERATURE SOLID-FILM LUBRICANTS**  
 R. H. McDaniel. Kirtland AFB, N. Mex., AF Weapons Lab., Feb. 1965. 128 p refs  
 (Contract AF 29(601)-6213)  
 (FZK-212; WL-TR-64-158; AD-613561)

Nuclear reactor irradiation and laboratory testing were performed on five high-temperature solid-film lubricants. The specimens were exposed to an average gamma dose of  $2.2 \times 10^{11}$  ergs/gm(C) and associated neutrons of  $5.2 \times 10^{16}$  n/cm<sup>2</sup> ( $E > 2.9$  MeV). Several test temperatures were investigated for each lubricant. Weibull plots and a ranking method were employed for data analysis. Reactor radiation had no significant effect on the wear life of the PbS + MoS<sub>2</sub> + B<sub>2</sub>O<sub>3</sub> or the CaF<sub>2</sub> lubricants. However, detectable decreases in wear life were noted at 80° F for Dynalube and at 900° F for Almasol SFD-810. The wear life of MoS<sub>2</sub> + graphite + sodium silicate suffered a decrease at 80° F but improved at 600° and 1200° F.

Author

**N65-22440\*#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**METHOD OF OBTAINING MULTIFUNCTIONAL ADDITIVES TO LUBRICATING OILS**  
 A. I. Kartashevskiy and E. S. Tetel'baum. 18 Mar. 1965. 51 p. Transl. into ENGLISH from Russian Patent no. 160251 (Appl. no. 811718/23-4), 2 Jan. 1963. 1 p  
 (FTD-TT-64-1087/1; AD-613175)

The object of the invention is a method of obtaining multifunctional additives for lubricating oils. Products of the oxidation of paraffine were treated with pentasulfide of phosphorus with subsequent neutralization of the product obtained in the presence of alkylphenol compounds.

TAB

**N65-22441#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**SOLID MOLYBDENUM DISULFIDE LUBRICANT**  
 Ye. I. Berniker. 18 Mar. 1965. 6 p. Transl. into ENGLISH from Mashinost (Kiev), no. 2, 1964. p. 25  
 (FTD-TT-64-1148/1; AD-613178)

The use of solid molybdenum disulfide (MoS<sub>2</sub>) as a lubricant for increasing the staying power and capacity of cutting tools as gear wheel cutters, and for the frictional parts of machines such as press fits is reported. Solid MoS<sub>2</sub> can be applied by spraying under pressure, smearing, or in the form of pressed pencils. Solid MoS<sub>2</sub> can be used in a vacuum, or at temperatures from 70° to 380° C; it is not a conductor of electricity, and does not collect dust. The use of the solid lubricant for bearings showed the possibility of using these lubricants for improving conditions of machining metals by cutting and pressure. The resistance of gear wheel cutters increased from 50% to 100% and the percentage of cutters required for finishing off unevenness was lowered from 50% to 5%. Lubrication of operating files with a colloid solution of MoS<sub>2</sub> in alcohol increased the production of files by 50% to 66%.

S. C. W.

**N65-22484#** Aberdeen Proving Ground, Md. Army Coating and Chemical Lab.  
**STORAGE STABILITY OF BRAKE FLUIDS** Final Report  
 C. B. Jordan. 23 Feb. 1965. 10 p refs  
 (CCL-176; AD-458510)

The stability of corrosion inhibiting systems found in brake fluids after extended storage of the fluids in steel and glass containers was investigated. Corrosion and oxidation stability tests were conducted on 22 approved fluids after 2 1/2 years storage in 5-gallon steel containers and on 8 approved fluids after 5 years storage in 1-gallon glass containers. In all tests conducted there was evidence of inhibitor instability or depletion. Sixteen of the 22 fluids stored in cans and 5 of the 8 fluids stored in glass failed to meet minimum requirements of specification.

Author

**N65-22556\*#** IIT Research Inst., Chicago, Ill. Mechanical Engineering Div.  
**FEASIBILITY STUDY OF TECHNIQUES TO PROTECT MECHANISMS OPERATING IN SPACE FROM MALFUNCTION. PART I: SURVEY AND ANALYSIS** Final Report.  
 28 Jun. 1963-27 Jun. 1964  
 W. E. Jamison. 30 Nov. 1964. 88 p refs  
 (Contract NAS8-11014)  
 (NASA-CR-62281; K-6055, Pt. I) CFSTI: HC \$3.00/MF \$0.75

A literature survey and analysis of currently available anti-friction techniques for space mechanisms were conducted to determine their operational characteristics and limitations in terms of environmental parameters. The techniques are assessed for their underlying theoretical principles and predictions are made of their performance potentials. It is con-

cluded that significant improvements in performance of space mechanisms must be preceded by a better understanding and control of friction and wear properties of interfaces. Specific recommendations are made for research and development to accomplish this

Author

**N65-22557\*** # IIT Research Inst., Chicago, Ill. Mechanical Engineering Div.

**FEASIBILITY STUDY OF TECHNIQUES TO PROTECT MECHANISMS OPERATING IN SPACE FROM MALFUNCTION. PART II: EXPERIMENTAL RESULTS AND RECOMMENDATIONS** Final Report, 8 Jun. 1963-27 Jun. 1964 W. E. Jamison Jan. 1965 50 p refs

(Contract NAS8-11014)

(NASA-CR-62282; C-6055, Pt. II)

Studies were conducted to establish techniques for providing a composite picture of friction interface as it relates to the friction process. Techniques used were X-ray diffraction, contact potential measurements, and residual gas mass spectrometry. Parameters investigated were (1) interfacial molecular composition; (2) crystal lattice spacing; and (3) surface contact potential as affected by sliding and by adsorption of gaseous species. It was shown that techniques used contributed significantly to the understanding of the fundamental processes involved in friction, and to the development of interfaces with low friction properties. The use of ultra-high vacuums extended the time available for measurements of gas-surface interactions. Contact potential measurements provided a convenient, speedy means for characterizing the electrical state of friction surfaces and for quantitatively defining adsorption processes when used in conjunction with partial pressure measurements. Other techniques being developed for friction studies on a molecular scale are low energy electron diffraction, secondary electron emission, and field emission microscopy

S.C.W.

**N65-22558\*** # Aerojet-General Nucleonics, San Ramon, Calif. **SNAP-8 MERCURY CORROSION AND MATERIALS RESEARCH, VOLUME III** Topical Report, Jun. 1960-Dec. 1962

M. F. Parkman, B. E. Farwell, D. K. Whaley, and R. V. Arabian Sep. 1963 96 p refs *Its Rept.*-2517

(Contract NAS5-417)

(NASA-CR-62349, AN-TM-192) CFSTI: HC \$3.00/MF \$0.75

Mercury corrosion of Haynes Alloy No. 25, Type 405 stainless steel, AM 350, 9Cr-1Mo and Cb-12r thermal convection capsules was investigated between 1000 and 10000 hours at 1025° F and 1100° F and between 500 and 2000 hours at 1175° and 1250° F. Isothermal capsules of Haynes 25 and Type 405 stainless steel were operated for 5000 and 1000 hours. Thermal convection capsules were heated at the bottom and cooled at the top to create a thermal gradient of 85° to 150° F. Penetration of the bottom half of the Haynes 25 thermal convection capsules increased with time and temperature up to 2 1/2 mil maximum at 1175° F. Tensile specimens machined from the Haynes 25 capsules after test were pulled and indicated that the material age hardened after exposure at 1175° and 1250° F. Mass transfer deposits, much smaller than in Haynes 25 capsules, occurred along the top half of the Type 405 stainless steel capsules, increasing in amount with time and temperature.

Author

**N65-22641\*** # General Dynamics/Astronautics, San Diego, Calif. Materials Research Group **INVESTIGATION AND ANALYSIS OF THE ELECTROPOLISHING PROCESS FOR SATURN DUCTING** Final Report, 15 Mar.-31 Dec. 1962

E. W. Gross 31 Jan. 1963 82 p refs

(Contract NAS8-818)

(NASA-CR-57864, AE63-0013) CFSTI: HC \$3.00/MF \$0.75

Type 321 and Type 302 stainless steels and certain high-nickel alloys were electropolished in a series of formulated and vendor baths. After electropolishing, samples were subjected to investigation and analyses including salt spray, salt atmosphere, and sea-coast environment corrosion tests, profilometer, and weight-loss measurement tests. The immersion and impingement methods of electropolishing were evaluated for use on propellant ducting and flexible metal hoses and sections of bellows. Electropolishing greatly increases the resistance of stainless steels to corrosion. Nine types of organic coatings were evaluated for protection of propellant ducting at cryogenic temperatures. Air-drying epoxy and acrylic formulations were found satisfactory for large assemblies that cannot be baked, and a heat curing modified silicone resin was found best for small assemblies or parts that can be baked. The impingement method of electropolishing, whereby large parts can be polished, was proven successful.

Author

**N65-22774\*** # Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**EFFECT OF ADDITIVES ON THE ANTIWEAR PROPERTIES OF FUELS**

G. I. Kichkin, I. V. Rozhkov et al 11 Feb. 1965 15 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 6, 1963 p 60-65

(FTD-TT-64-937/1+2; AD-611531)

Of the investigated jet fuels the best antiwear properties are had by the fuel R-1; the worst by the fuel T-2. With the rise in the temperature within the limits of 20° to 150° C the antiwear properties of the fuel deteriorate considerably. With the addition to the fuel in small concentration (0.01% by weight) of antiwear substances developed for oils the antiwear properties of the fuel are improved almost to the same level as with the addition to the fuel of antioxidants and stabilizer-dispersants. The adding to fuels for jet engines of some types of surface-active substances—phenols, alkylphenols, phenylene-diamines—makes it possible at the same time to improve their stability during storage and improve their antiwear properties. TAB

**N65-22886\*** # Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**EFFECT OF LIQUID SODIUM ON ENDURING STRENGTH OF STRUCTURAL MATERIALS**

G. P. Dykova and V. I. Nikitin 15 Feb. 1965 12 p refs Transl. into ENGLISH from Zhidkiye Metally Sb. Statey (USSR), 1963 p 292-299

(FTD-TT-64-1210/1; AD-611424)

The durable strength in liquid sodium and in air of EI-851 steel at 700°, EI-869 alloy at 750° and EI-437 B alloy at 800° was determined. The absence of liquid metal effect on the durable strength and creep of EI-851 steel and EI-869 alloy was shown. The EI-437 B alloy revealed a reduction in durable strength and plasticity and an increase in rate of creep at all periods in a liquid metal medium. It was established that the dependence of time prior to destruction and rate of creep upon the stress applied to EI-437 B alloy in liquid metal is gradual, just as it is in air. It was shown, that the effect of liquid sodium on durable strength and creep of EI-437 B alloy at 800° is determined by the adsorption properties of the medium, the detected adsorption effect of liquid metal confirmed the mechanism of overcreeping of dislocations under creep conditions.

TAB

**N65-22928\*** # Naval Air Station, Pensacola, Fla. Materials Engineering Div.

**EFFECTIVENESS OF THE SPECTROMETRIC OIL ANALYSIS METHOD FOR MONITORING AIRCRAFT MECHANISMS**

B. B. Bond 26 Jun. 1964 10 p ref

(OA-20-64; AD-609746)

An investigation of the potentialities of the spectrometric oil analysis method for monitoring aircraft engines and other aircraft mechanisms is reported. The reliability of the method for detecting abnormal wear in oil lubricated aircraft mechanisms, such as metal parts in frictional contact, is discussed. The applicability of the oil analysis technique to turbojet engines was also evaluated. Results of a study on seven discrepant jet engines showed these facts: (1) Oil analysis provided preindications of failure in six of the seven engines. Other evidence of failure was found in only two of the seven. (2) Oil analysis provided warnings in time to avert inflight failures in four of the engines. Delay in transit time of oil samples for two of the remaining three engines prevented a more thorough study. (3) Two of the three inflight failures resulted in total loss of the aircraft. Oil analysis is credited with the detection of two of the discrepant engines that did not fail in flight.

S.C.W.

**N65-22936#** Naval Air Station, Pensacola, Fla. Materials Engineering Div.

**INVESTIGATION OF THE FEASIBILITY OF AN AIRCRAFT-OIL ANALYSIS SYSTEM FOR OPERATIONAL USE IN THE FIELD, PHASE II**

B. B. Bond 14 Sep. 1964 8 p refs Review of TRECOM TR-63-55

(OA-37-64; TRECOM-TR-63-55; AD-609743)

A critique is presented on a previous statistical study to evaluate oil analysis for wear metals as a method for detecting incipient failure in aircraft engines. It was shown that the sole basis for the statistical study was the segregation of the engines into three groups. Therefore, the validity of the study must depend upon the ability to classify each engine as belonging in one of the three groups. As the basic information that would make such classifications possible was not available, the conclusions of the statistical study are not valid. Therefore, another program for evaluating the oil analysis program is discussed for reciprocating engines. Statistical data are presented for a 4-year period from October 1, 1959 to October 1, 1963, and for the 1-year period from October 1, 1962 to October 1, 1963.

E.E.B.

**N65-23103#** Argonne National Lab., Ill. Metallurgy Div.  
**CORROSION OF EXPERIMENTAL THORIUM-BASE ALLOYS**

James Y. N. Wang Feb. 1965 13 p refs

(Contract W-31-109-ENG-38)

(ANL-7006) CFSTI: \$1.00

Some 50 high-purity, binary and ternary, thorium-base alloys were prepared and corrosion tested in distilled water between 120° and 260°C. Data indicated that the addition of titanium improved corrosion life of Th-1 wt% C and Th-0.5 wt% C binary alloys at 260°C. Additions of aluminum from 3 to 7 wt% appeared beneficial. At 200°C, a Th-10 wt% Y alloy exhibited a low corrosion rate during a short period of exposure. The corrosion resistance of all thorium-uranium alloys in increments of 5 wt% uranium, to the maximum 40 wt% uranium, was poor. The addition of 4 wt% zirconium to Th-15 wt% U caused an improvement at 200°C. Author

**N65-23264#** International Lead Zinc Research Organization, New York.

**ILZRO RESEARCH DIGEST NO. 15, OCTOBER 1, 1964 TO APRIL 1, 1965. PART IV: LEAD METALLURGY**

1 Apr. 1965 42 p refs

The articles on lead technology reviewed include the following: asbestos pads for vibration attenuation, sound attenuation, plumbing, continuous sheet lead casting, roofing, acoustical use in European building partitions, flame spraying of low-temperature porcelain enamels, concrete coatings, conversion of particulate lead to wrought forms, composite

cable sheathing, metal fiber reinforcement, adhesive joining of lead, plating on steel, power metallurgy, lead acid batteries, joining of particulate lead products, corrosion, fatigue cracking, properties of molten lead and lead alloys, fatigue stress and surface reactions of lead, dynamic properties of lead and lead alloys, and surface reactions of lead. Also, completed programs and articles, and presentations by the staff and contractors are included.

E.E.B.

**N65-23434** Library of Congress, Washington, D. C. Aerospace Technology Div.

**INTENSIFICATION OF COMBUSTION PROCESSES**

Paul Vantoch *In its Foreign Sci. Bull.*, Vol. 1, No. 5 May 1965 p 12-20 refs (See N65-23432 13-34)

Soviet studies related to the development of high-performance rocket and ramjet combustors are reviewed, and the following approaches to intensification of combustion processes are discussed: intensification of homogeneous combustion by specially designed flame holders and ignition sources; intensification of heterogeneous combustion by flash vaporization of the boiling fuel or oxidizer; and intensification of diffusion flames by interaction with transverse air jets. The theoretical concept of combustion in the predetonation regime is also discussed. Several studies dealing with the minimization of the combustion zone length in ramjets, particularly at high altitudes, are reviewed, and a comparatively recent source is cited in which for the first time the development of two fuel additives is claimed which considerably improved burning characteristics at low pressures.

Author

**N65-23708\*#** Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.

**STRESS CORROSION CRACKING OF TITANIUM ALLOYS**

Progress Report, Apr. 1-Jun. 30, 1964

Sheldon P. Rideout, McIntyre R. Louthan, Jr., and Clifford L. Selby Aug. 1964 17 p refs

(NASA Order R-124; Contract AT(07-2)-1)

(NASA-CR-60194; DP(NASA)-917) CFSTI: HC \$1.00/MF \$0.50

Results of research work to determine the mechanism of hot-salt stress corrosion cracking of titanium alloys are given. Exploratory tests were started with radiotracer <sup>36</sup>Cl to determine the role of chloride in the corrosion cracking phenomenon. Direct observations were made of salt reaction with Ti-8Al-1Mo-1V alloy at various temperatures. Electron microscopy studies were started to determine the relationship between alloy structure and crack morphology. Preliminary results indicate that a small amount of HCl gas is given off during dehydration of sea salt heated to 650°F. The HCl gas and/or resultant hydroxides may be involved in initiation of stress corrosion cracking. Crack examinations revealed the following: cracks propagate along alpha phase grain boundaries and alpha-beta phase interfaces; they appear to propagate by chemical attack with no evidence of mechanical rupture. The beta phase is cathodic to the alpha matrix and is contained unattacked within corrosion products in stress corrosion cracks.

Author

**N65-23819\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**APPARATUS FOR STUDYING BALL SPINNING FRICTION**

Steven T. Miller, Richard J. Parker, and Erwin V. Zaretsky Washington, NASA, May 1965 13 p refs

(NASA-TN-D-2796) CFSTI: HC \$1.00/MF \$0.50

An apparatus was designed to study one aspect of spinning friction based on interfacial slip over the entire ball-race contact area. It is capable of measuring spinning moments of less than 0.01 inch-pound at maximum Hertz contact stresses

to over 400000 psi, speeds to 3500 rpm, and under varying contact configurations and conditions. From the torque measurement, a coefficient of spinning friction can be calculated. The apparatus comprises a drive assembly, a deadweight load assembly, a spherical upper test specimen, a cylindrically grooved lower test specimen of varying conformity, a lower test specimen housing assembly incorporating a hydrostatic air-bearing assembly, and a torque-measuring system. In operation, the upper test specimen is loaded against the lower test specimen through the drive shaft assembly by the deadweight load assembly. As the drive assembly is rotated, the upper test specimen rotates against the stationary lower test specimen actuating the torque-measuring system. Preliminary tests showed that the coefficient of spinning friction decreased with increasing maximum Hertz stress to an intermediate stress level. Author

**N65-23867#** Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).

**INFLUENCE OF SURFACE TREATMENT ON THE CORROSION OF CARBON STEEL AND STAINLESS STEEL IN HIGH TEMPERATURE WATER AND STEAM. PART I: RESULTS OF AUTOCLAVE TESTS [INFLUENCE DU TRAITEMENT DE SURFACE SUR LA CORROSION D'ACIERS AU CARBONE ET INOXYDABLE DANS L'EAU ET LA VAPEUR A HAUTE TEMPERATURE. PARTIE I: RESULTATS DES ESSAIS EN AUTOCLAVE]**

M. Warzee, J. Hennaut, M. Maurice, J. Waty, and Ph. Berge Brussels, EURATOM, 1964 37 p refs In FRENCH, ENGLISH summary

(Contract EURATOM-089-62-7 RDB)

(EURAC-1038, EUR-1735.f) Available from Belg. Am. Bank and Trust Co., New York, Account No. 22 186. 40 Belg. Fr.

Austenitic 18-10 stainless steel with 0.04% carbon (AISI 304) and a low alloy boiler steel grade were basic materials. Four distinctly different states compared were mill-machined, ground, machine-polished up to grade 600, and electrolytically polished in an acetoperchloric solution. The influence of the surface state was investigated by static autoclave tests in water at 300°C and in steam at 400°C-200 kg/cm<sup>2</sup>, during periods of 300, 1000 and 2000 hours. An influence, significant of the surface state, was revealed in all the examined cases. The major fact relative to this influence is its differentiated character according to the nature of the steel and the oxidation conditions. As concerns the low alloy steel, the surface state has a similar influence in water at 300°C and steam at 400°C. Electrolytic polishing allows lowering the corrosion rate by approximately a factor of two as compared to ground and machine polished states. Tests on an austenitic 18-10 stainless steel provide quite different conclusions. If the fact that electrolytic polishing leads to an important improvement in water at 300°C, it appears on the other hand that this surface treatment is baleful in steam at 400°C. Author

**N65-24010#** Royal Aircraft Establishment, Farnborough (England).

**FURTHER EXPERIMENTS ON THE ATMOSPHERIC STRESS-CORROSION OF ALUMINIUM ALLOYS**

G. Meikle London, Min. of Aviation [1963] 45 p refs (RAE-MET-PHYS-96)

Further experiments on atmospheric stress corrosion were made using material from large forged blocks, and the effects of heat treatment variations studied. The aluminum-zinc-magnesium type of alloy was shown to respond to heat treatment variations when stressed in the long transverse direction but poor stress-corrosion results were obtained generally in the short transverse direction except with heat treatments that gave relatively poor tensile properties. The most satisfactory treatment to give good resistance to stress corrosion is one involving quenching from the solution temperature into

molten salt at 180°C. The short transverse creep properties determined at room temperature were found to be worse than those in the long transverse direction. The aluminum-copper type of alloy was found to have good stress-corrosion properties, even in the short transverse direction. Author

**N65-24158** Joint Publications Research Service, Washington, D. C.

**ON THE PROBLEM OF EVALUATING THE RELIABILITY OF MEASUREMENT**

V. P. Kontorovich. In *its Izv. VUZov: Instr. Bldg.*, Vol. VIII, No. 1, 1965 17 May 1965 p 48-52 refs (See N65-24150 13-09) CFSTI: \$6.00

The aging and wearing out of elements of a measuring device lead to additional errors and, consequently, to a change in the given error of the results of measurements. The magnitude of the increase in the latter may be selected as the quantitative characteristics of reliability. The principal connection between the given error because of wear and aging and the change in the quantity of information arriving from the measuring device is shown. Author

**N65-24215#** Rock Island Arsenal Lab., Ill.

**CONTROL OF STRESS CORROSION Second Interim Report**

R. H. Wolff 18 Jan. 1965 15 p refs

(RIA-65-152; AD-613652) CFSTI: \$0.50

This study of the control of stress corrosion cracking susceptibility of steels by application of protective coatings was designed to use abrasive blasted specimens to simulate more nearly the surfaces and conditions of a manufacturing operation. Bent beam specimens of 4130, 6150, and 18%-nickel maraging steel were prepared at yield strength levels of 204, 231, and 316 ksi, respectively, for test at 75% of yield strength. Test atmospheres were outdoor, high humidity and salt spray (5%), and cycles of these alternating between salt spray, humidity and air. Cycle tests produced more rapid failure than single environments. Abrasive blasting extended the time to failure as compared to nonblasted uncoated specimens. Coated specimens were electroplated with zinc, zinc phosphatized, or brushed with zinc-filled paint. Specimens of 4130 steel had not failed in over a year in outdoor exposure and 6 months in high humidity. Failures were noted with all the materials in cycle tests with indication of extended time to failure as a result of using zinc-filled paint. Author

**N65-24285#** Siemens-Schuckertwerke A. G., Erlangen (West Germany).

**RESEARCH ON ZIRCONIUM HYDRIDE IN ZIRCALOY-2 AND ZrNb ALLOYS [UNTERSUCHUNGEN UBER ZIRKONHYDRID IN ZIRCALOY-2 UND ZrNb-LEGIERUNGEN]**

Brussels, EURATOM, Feb. 1965 43 p In GERMAN; ENGLISH summary

(Contract EURATOM-024-61-10 RDA)

(EURAC-1161; EUR-2013.d) Available from Belg. Am. Bank and Trust Co., N. Y., Account No. 22 186. 60 Belg. Fr.

Test bars of alloys of Zircaloy-2, ZrNb1, ZrNb2.5, ZrNb1Cu1 and ZrCu0.5Mo0.5 were prepared by vacuum melting, electron beam melting or argon melting and tested in different states: 25% cold-worked, annealed in  $\alpha$ -phase and annealed in  $\beta$ -phase with slow cooling. The corrosion tests were carried out in water vapor at 500°C, 1 atm and in water under pressure at 350°C, 168 atm. Measurements were carried out to determine the corrosion speed and the relative and absolute hydrogen pickup in these alloys. A comparative micrographic study was conducted on the oxide film and the structure of the hydrides formed both on the samples corroded in water and steam and on those artificially charged with hydrogen up to contents of around 2000 ppm. The influence of the hydrogen content on the mechanical properties was determined in the

case of the artificially charged samples. The results confirm the satisfactory behavior of Zircaloy-2 in water at 350°C and the superiority of ZrNb alloys and particularly ZrNb2.5 and ZrCu0.5Mo0.5 in steam at 500°C. Author

**N65-24415#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div  
**RESULTS OF AZNII NP OPERATION IN THE FIELD OF SYNTHESIZING, STUDYING AND APPLICATION OF AD-MIXTURES TO LUBRICATING OILS**

A. M. Kuliyeu. 28 Jan. 1965. 13 p. Transl. into ENGLISH from Tr. Tret'ey Vsesoyuznoy Konf. po Treniyu i Iznosu V Mashinakh (USSR), v. 3, 1960. p. 366-373 (FTD-TT-64-860/1+2, AD-610651)

An analysis of research focuses on the technological development of additives for improving the quality of lubricating oils is presented. Data are included on the synthesis of depressant additives for reducing the freezing point of oils, the synthesis of multifunctional additives including sulfonate, alkylphenyl, combined, and complex action additives, the synthesis of additives which increase the strength of oily films and improve their lubricating qualities, the synthesis of stabilizing additives, and the susceptibility of oils and individual groups of hydrocarbons to various additives. S. C. W.

**N65-24445#** Battelle Memorial Inst., Columbus, Ohio. Defense Metals Information Center  
**STRESS-CORROSION CRACKING OF ALUMINUM ALLOYS**

James D. Jackson and Walter K. Boyd. 15 Feb. 1965. 19 p. refs (Contract AF 33(615)-1121) (DMIC-MEMO-202, AD-613957)

Aluminum alloys most often associated with stress-corrosion cracking in actual service are 2014, 2024, 2219, 7075, 7079, and 7178 alloys, and cast alloys of Ternalloy 7, 40E, 195, and 220 compositions. The tensile stresses necessary to initiate stress-corrosion cracking may be either applied (as through static loads, press fits, or fasteners), or residual (such as from heat treatment or machining). The prevention of failure requires a basic knowledge of the phenomenon and of the relative resistance of the various alloys, and of the effect of grain structure on cracking susceptibility. Application of this knowledge and use of good practices in heat treatment, working, forming, machining, and design can reduce the incidence of stress corrosion. The application of compressive stresses such as by shot peening or the use of coatings offers an effective means of minimizing or at least delaying stress-corrosion cracking. Laboratory investigations of stress-corrosion cracking often involve C-ring or tensile specimens exposed by alternate immersion in 3 1/2% NaCl solution. Author

**N65-24640#** Pisa Univ. (Italy). Inst. of Applied Mechanics and Aeronautics  
**ON THE ELASTIC SLIPPING IN THE ROLLING OF SHAPES OF VARIOUS MATERIALS [SULLO SLITTAMENTO ELASTICO NEL ROTOLAMENTO DI CORPI DI MATERIALI DIVERSI]**

Marino Marini. 1964. 19 p. refs. In ITALIAN. *Its* 21st Ser., No. 1044

Elastic slipping and friction couplings between rollers or drums made of rubber and steel, perspex and steel, and aluminum and steel are examined. Transl. by P. F. E.

**N65-24709#** Argonne National Lab., Ill. Chemical Engineering Div  
**ENGINEERING DEVELOPMENT OF FLUID-BED FLUORIDE VOLATILITY PROCESSES. PART 7: THE CORROSION OF NICKEL IN PROCESS ENVIRONMENTS**

A. A. Chilenskas and G. E. Gunderson. Mar. 1965. 18 p. refs. (Contract W-31-109-ENG-38) (ANL-6979) CFSTI \$1.00

Corrosion studies in support of the fluoride volatility program are in progress using small-scale laboratory tests conducted in tube furnaces, and implant exposure tests. Results of both types of tests show the following: (1) Under conditions of low gas flow rates, where protective films easily form, corrosion rate of nickel by fluorine alternated with hydrogen chloride and fluorine alternated with oxygen is low (1-4 mils/yr) and in agreement with that of nickel for fluorine alone. (2) Where films form less readily or can be removed upon being formed, corrosion rate is significantly higher than under static conditions, but less than would occur if no protective film formed. Corrosion rate of nickel is shown to increase due to the presence of a fluidized bed. (3) Under static conditions for long-term exposure, welds made with nickel-200 metal filler were shown superior to those made with nickel-61 filler metal and corrosion rates of welds made with nickel-200 range from 1 to 5 mils/yr (comparing closely with corrosion rate for nickel plate, while welds made with nickel-61 filler metal ranged from 67 to 1315 mils/yr. Some evidence indicates a small amount of titanium in nickel filler metal-61 causes high corrosion rates. (4) Specimens examined metallographically exhibited little or no evidence of intergranular attack. Several specimens from implant tests showed a few areas where apparent intergranular attack of 1 to 2 mils occurred. (5) Thermal cycling of a specimen exposed to process environments had little or no effect upon corrosion rate, neither did exposure of specimen to air after each process cycle. Author

**N65-25409#** Oak Ridge National Lab., Tenn.  
**SNAP-8 CORROSION PROGRAM. Quarterly Progress Report, Period Ending 28 Feb. 1965**

H. W. Savage, E. L. Compere, R. E. MacPherson, W. R. Huntley, and A. Taboada. Jun. 1965. 44 p. refs (NASA Order C-220-A, Contract W-7405-ENG-26) (NASA-CR-63196, ORNL-3823) CFSTI. HC \$2.00/MF \$0.50

Hydrogen solubilities in NaK-78 were determined for a temperature range of 572° to 1300° F as a function of hydrogen pressure from a few millimeters to 1 atm. and Sievert's law was found to hold for this system. Evidence of solid hydride precipitation was observed below 752° F. For estimated hydrogen pressures in the SNAP-8 primary coolant, these data indicate a hydrogen concentration in the NaK of 1 ppm and precipitations of solid hydrides at about 300° F. Also, the ratio of permeability of deuterium and hydrogen through type 316 stainless steel was found to be 0.68 at 1100° F and 0.74 at 1300° F. Further, studies of the phase equilibria of the Na-K-Li-H system at 1100° F indicate that in all cases the addition of lithium greatly lowers the partial pressure of the hydrogen at equivalent hydrogen concentrations. This is apparently due to the hydrogen combining with the alkali metals in proportion to their concentration and affinity for hydrogen. The limited solubility of lithium hydride results in precipitation, which inhibits the pressure changes until available lithium is exhausted. E. E. B.

**N65-25472#** Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.  
**STATIC TESTS OF CORROSION INHIBITORS FOR ALUMINUM AND CARBON STEEL**

R. B. Richman. Feb. 1965. 28 p. refs (Contract AT(45-1)-1830) (BNWL-29) CFSTI \$2.00

Uniform corrosion losses and pitting tendencies were measured for carbon steel and aluminum samples exposed for as long as 9 1/2 months at ambient temperature in static, non-refreshed solutions of 38 different inhibitor mixtures. Results



from these tests indicate that two inhibitors, (1) sodium hexa-meta-phosphate, and (2) sodium nitrite plus sodium silicate, are possible candidates to replace sodium dichromate in dynamic or static systems that contain both carbon steel and aluminum. Three additional inhibitors reduced the uniform corrosion of carbon steel. Limited measurements of inhibitor depletion were obtained, but the effects of this depletion on corrosion were not defined. Candidate mixtures should be tested in dynamic systems at temperatures typical of Hanford reactor operation, to confirm the indications of satisfactory corrosion inhibition shown by these static tests. Author

**N65-25517#** Oak Ridge National Lab., Tenn.

**TYPE 316 STAINLESS STEEL, INCONEL, AND HAYNES ALLOY NO. 25 NATURAL-CIRCULATION BOILING-POTASSIUM CORROSION TEST LOOPS**

D. H. Jansen and E. E. Hoffman Jun. 1965 102 p refs  
(Contract W-7405-ENG-26)  
(ORNL-3790) CFSTI: \$4.00

An investigation was undertaken to determine the compatibility of conventional nickel-, iron-, and cobalt-base high-temperature alloys with boiling potassium. The tests were designed to obtain quantitative information on the dissolution of the container alloys by condensing potassium and the subsequent deposition of solute in a subcooled liquid region of the test device. Studies were conducted in natural-circulation loops, two of which were fabricated from type 316 stainless steel, two from Haynes alloy No. 25, and one from Inconel. Each of the alloys was operated at a maximum boiler-condenser temperature of 870° C for 1500 to 3000 hr, and the Haynes alloy No. 25 was also tested for 3000 hr at 980° C. The potassium condensing rates at the two temperatures were 170 to 180 and 300 g/min, respectively. At 870° C, type 316 stainless steel and Haynes alloy No. 25 exhibited comparable resistance to attack by boiling potassium, while Inconel showed greater deterioration. Carbon was transferred from the condensing region to the subcooled liquid region in all the loop tests. Attendant with this, the elongation of the material decreased and the tensile strength increased. No evidence of preferential leaching of major metallic constituents of these alloys was detected by electron microprobe analysis of the condenser surfaces. However, limited mass transfer from the hot region to the cold region was noted. Author

**N65-25522#** Martin Co., Baltimore, Md. Nuclear Div.

**SNAP 19 PROGRAM. EJECT MECHANISM COLD WELDING EVALUATION**

S. Podlaseck May 1965 12 p refs  
(Contract AT(30-1)-3169)  
(MND-3169-66)

The potential cold welding at metal contacting surfaces of the SNAP-19 eject mechanism and the use of lubrication in eliminating this problem are discussed. The prime areas of concern are the backup nut piston, assembly interface, the piston cylinder interface, the guide pin-guide pin slot interface, and the release bolt-upper spring interface. A molybdenum disulfide solid film lubricant, its application techniques, expected lifetime, and frictional characteristics in a space environment are examined. Weight losses through sublimation and dissociation are immeasurably small for the expected lifetime at temperatures below 200° F. The lubricant's behavior is more desirable and more predictable in a vacuum than under normal atmospheric conditions. A dry film coating applied to the piston assembly and upper spring assembly will eliminate all interfacial contact problems in the eject assembly. R.N.A.

**N65-25889#** Bureau of Mines, Pittsburgh, Pa. Explosives Research Center  
**IGNITION CHARACTERISTICS OF FUELS AND LUBRICANTS** Summary Report, 1 Jan.-31 Dec. 1964

Joseph M. Kuchta and Ralph J. Cato Mar. 1965 57 p refs  
(Contract DO-33(657)-63-376)  
(AFAPL-TR-65-18; AD-613050)

Hot surface ignition temperature data are presented for n-hexane, n-octane, n-decane, JP-6 jet fuel and aircraft engine oils MIL-L-7808 (O-60-18) and H-1026 in various oxygen-nitrogen atmospheres (2.5 to 100 volume percent oxygen) under stagnant or near-stagnant flow conditions. Minimum ignition temperatures were found to increase with decreasing oxygen concentration. In vessel ignitions, these temperatures increased with decrease in fuel contact time and with increase in surface area/volume ratio. In wire ignitions, the minimum ignition temperatures increased with decrease in wire diameter, length/diameter ratio, and initial mixture temperature. Expressions have been developed to define the ignition temperatures as a function of the above pertinent variables. Hot gas ignition temperatures of the above combustibles were also found to vary with the heat source diameter, for 1/8, 3/8 and 1/2-inch diameter jets. Furthermore, they do not differ greatly from hot surface ignition temperatures for comparable heat source diameters. The hot gas jet temperatures required to produce "hot" flames and pseudo or "cool" flames varied noticeably more than did the corresponding heat flux values. In oxidation studies with n-octane vapor air-mixtures, rates of pressure rise were found to vary as the 0.38 power of the fuel concentration (5 to 30 volume percent) and as the 1.4 power of the initial total pressure (0.6 to 13 psia) at temperatures between 428° and 536° F. The temperature dependency of the rates in these studies was similar to that obtained in the ignition temperature experiments. Author

**N65-26040#** Bureau of Mines, Albany, Oreg. Metallurgy Research Center

**STAINLESS STEEL-GADOLINIUM ALLOYS**

M. Copeland, W. Barstow, C. Armantrout, and H. Kato Sep. 1964 34 p refs  
(Contract AT(11-1)-599)  
(BM-RI-6636)

Phase relations of gadolinium alloyed, up to 40 weight-percent (wt pct), with AISI 304-type stainless steel were established. Body- and face-centered cubic iron-rich solid solution phases and several intermetallic gadolinium-containing compounds of variable composition that approximated the formulas Fe<sub>9</sub>Gd, Ni<sub>7</sub>Gd<sub>2</sub>, Ni<sub>3</sub>Gd, Fe<sub>2</sub>Gd, NiGd, and NiGd<sub>3</sub> were identified. The intermetallic phases Fe<sub>9</sub>Gd and Ni<sub>7</sub>Gd<sub>2</sub> were noted to melt at about 1,080° C at about 0 to 2 wt pct gadolinium. The melting temperature of Fe<sub>9</sub>Gd increased with increasing gadolinium content to a plateau at about 1,230° C and 30 wt pct gadolinium and the melting point of Ni<sub>7</sub>Gd<sub>2</sub> decreased to a plateau at 900° C and 30 wt pct gadolinium where Ni<sub>3</sub>Gd, NiGd, and Fe<sub>2</sub>Gd coexist. Body-centered cubic iron solid solution was stable from 1 to 2 wt pct gadolinium to higher contents, 30 wt pct gadolinium or possibly more, and face-centered cubic iron up to 12 wt pct gadolinium below 1,200° C. The stability of these phases above 1,200° C was not resolved except for the melting points. A limited number of fabrication variables as well as mechanical and corrosion properties of alloys containing up to 5 wt pct gadolinium were studied. Equilibrating and forming operations were best conducted at about 940° to 1,080° C. Some variability in the yield and tensile strengths of alloys was noted; however, there was a continual decrease in ductility and impact resistance with increasing gadolinium contents. The resistance of gadolinium alloys to corrosion in water at 354° C was about the same as stainless steel. Author

**N65-26072#** Midwest Research Inst., Kansas City, Mo.  
**FRICTION AND WEAR BEHAVIOR OF SOLID FILMS** Summary Technical Report, 1 Dec. 1963-1 Dec. 1964

Paul J. Bryant Wright-Patterson AFB, Ohio, AF Mater. Lab.  
Dec 1964 27 p refs  
(Contract AF 33(657)-10122)  
(AFML-TR-65-5; AD-614242)

Two current phases of research and the initiation of a third phase are described below. The phases consist of: (1) a study of cleavage energies and stress-relaxation effects for graphite in air, vacuum, and pure environments of relevance to lubrication phenomena; (2) measurements of the shear strength of graphite and the physical mode of failure under shearing motion; and (3) a detailed study of friction and wear process, including wear particle size measurements, in the pure relevant environments for graphite lubrication. The first phase has shown, from both theory and experiment, an unusually high binding energy for graphite. This high energy has been identified as the real reason for graphite's failure to exhibit intrinsic lubrication. The second phase has confirmed the conclusions drawn from the first study by showing a high shear strength for graphite. The third phase promises to give correlations between the basic properties of graphite, such as binding energy, and effects which are observed during actual frictional tests. Thus, all of the results from cleavage measurements, stress relaxation in various environments, and shear strength measurements will be correlated with the friction and wear studies to give a better understanding of lamellar solid lubrication. Author

**N65-26112#** General Motors Corp., Milwaukee, Wis. IMU Gimbal Group  
**INERTIAL GUIDANCE SYSTEM, WEAPON SYSTEM 107A-2, TITAN II MISSILE GUIDANCE SET, IMU AND MGC GUIDANCE CORROSION PROOFING**  
Thomas C. O'Connell 3 Aug. 1964 234 p refs  
(Contract AF 04(694)-177)  
(EP64-241; AD-460981)

Nonpolar coatings that cure only by the evaporation of a solvent are softened by exposure to  $N_2O_4$ . This softening allows  $N_2O_4$  permeation and substrate attack. Two coatings were shown to withstand exposure to  $N_2O_4$  fumes for 16 hrs at both high and low humidity levels; however, high-temperature curing is required for both coatings. Several air-dry coatings were cured at low-temperatures and exhibited good compatibility with  $N_2O_4$ ; however, these coatings softened during exposure to  $N_2O_4$ , and their value as a barrier coating over magnesium was lost. Also, anhydrous  $N_2O_4$  fumes soften organic films and cause substrate attack much more rapidly than when moisture is present. Successful resistance of an organic coating to  $N_2O_4$  is dependent upon a minimal coating thickness. In heat exchanger tests, no apparent degradation was noted in the heat exchange between the hot side and cold side after operating with dust-contaminated air. The net heat exchange increased as the test with dust-contaminated air progressed. The amount of dust introduced into the cold air inlet stream was equivalent to operating the heat exchanger for three years at a concentrations of 0.04 mg/lb air. E.E.B.

**N65-26208** Joint Publications Research Service, Washington, D. C.  
**ALL-UNION SCIENTIFIC AND TECHNICAL CONFERENCE ON PROTECTING CHEMICAL EQUIPMENT FROM CORROSION**

L. M. Kamionskiy *In its Soviet Conf. on Met. Probl.* 8 Jun. 1965 p 11-19 Transl into ENGLISH from Zashchita Metal. (Moscow), v. 1, no. 2, Mar.-Apr. 1965 p 249-253 (See N65-26205 15-15) CFSTI: \$3.00

A brief summary on the development of highly corrosive resistant steels, ceramic plates, cement and concrete linings, glass heat-resistant pipes, polymeric coating materials, and protective coatings made of liquid nairits is given, and their application to improve corrosion control in chemical production lines is discussed. G.G.

**N65-26280#** Oklahoma Univ. Research Inst., Norman.  
**BEARING AND LUBRICANT PROBLEMS Final Report, 1 Sep. 1962-31 Aug. 1963**  
Darrel G. Harden 3 Feb. 1964 68 p  
(Contract AF 34(601)-14089)  
(AD-429247)

Three general and eight specific problems are presented in the development of bearings and lubricants. The general problems include the development of a petroleum base lubricant for KC-97 and B-50 aircraft superchargers with improved viscosity-volatility and viscosity-temperature characteristics, development of improved turbosuperchargers storage preservatives, and testing of a synthetic lubricant used in a constant speed drive system. The specific problems discussed are the suitability of grade 1100 aviation oil after contamination with aviation gasoline, determination of a suitable lubricant for use in ram air turbines and for lead screws of missile attitude stands, inspection of J79/F104 Teleflex box bearings, engineering study of ballbearings P/N VI-224248, inspection of bearings from air turbine assembly P/N 202280 and 202290, investigation of pour point of refrigerator compressor oils, freezing prevention in an evaporative heat exchanger by using constant boiling mixtures, and determination of a suitable high temperature lubricant for swivel joints in the hot air bleed line of KC-97 superchargers. R.N.A.

**N65-26290#** Naval Research Lab., Washington, D. C. Chemistry Div.  
**REDUCTION OF POLYMERIC FRICTION BY MINOR CONCENTRATIONS OF PARTIALLY FLUORINATED COMPOUNDS**  
R. C. Bowers, N. L. Jarvis, and W. A. Zisman 1 Mar. 1965 19 p refs  
(NRL-6227; AD-614059) CFSTI: \$0.50

A new approach to the reduction of boundary friction in solid polymers has been studied. Dry frictional properties of several classes of polymeric solids have been reduced significantly by the addition of small proportions of a suitably designed surface-active compound. Appropriate fluorocarbon derivatives have been prepared and found effective in poly-methyl methacrylate, polyvinyl chloride, and in several polyvinylidene chloride copolymers. These addition agents are effective both in polymer films prepared by evaporation from a solvent and in thick disks prepared from the melt. The low-energy surfaces formed by the fluorinated additives may also be self-healing, that is, any surface-active molecule lost from the film may be replaced by the diffusion of additional material to the interface. The decrease in friction caused by the addition agent is accompanied by an increase in the equilibrium contact angle of each of several liquids on the polymer surface. The small proportion of addition agent used causes only a small decrease in the hardness of the polymers. There are many promising applications of this technique to specific problems in lubrication and adhesion. Author

**N65-26345#** Bureau of Reclamation, Denver, Colo. Chemical Engineering Branch  
**CORROSION INVESTIGATIONS, TRACY-RED BLUFF, CALIFORNIA. EHV DIRECT-CURRENT TESTS**  
T. E. Backstrom 15 Sep. 1964 32 p  
(ChE-34; AD-609766)

One important test in a series of EHV d-c transmission tests using a ground return system performed between Tracy and Red Bluff, California, was the evaluation of the effect of introduction of direct current into the ground on the corrosion of buried metalwork. Test measurements were made to determine the maximum distance from the two types of electrodes at which corrosion prevention procedures would be necessary for protecting buried metallic structures. It was concluded that the use of EHV d-c ground return at current levels used in the

tests would: 1/ promote serious corrosion of buried metalwork in Area 1 (within approximately 1/2-mile radius of the electrode) if a ground mat electrode were used and mild corrosion if a deep-well electrode were used; 2/ promote negligible to serious corrosion of buried pipelines in Area 2 (1/2-3 mile radius of either a ground mat or deep-well electrode) depending upon (1) the distance of the pipelines from the electrode (2) the geometry of the two electrode-pipeline systems and (3) the horizontal extent of the pipelines; 3/ impress no significant stray currents on buried pipeline in Area 3 beyond approximately a 3-mile radius of the electrode. Normal corrosion prevention techniques are fully adequate to prevent stray current corrosion of buried metalwork if proper location of the electrode is made. These conclusions must be modified to reflect the anticipated time-current product. Author

**N65-26564#** Fairchild Hiller Corp., Bay Shore, N. Y. Stratos Div.

**DEVELOPMENT OF GAS-ENTRAINED POWDER LUBRICANTS FOR HIGH-SPEED AND HIGH-TEMPERATURE OPERATION OF SPUR GEARS** Technical Report, Jun. 1962-Jan. 1964

S Wallerstein Wright-Patterson AFB, Ohio, AF Aero Propulsion Lab., May 1965 143 p refs  
(Contract AF 33(657)-8625)

(AFAPL-TR-65-24, AD-464626)

The feasibility of adapting powder lubricants to the operation of gears during relatively long periods of time under extreme environmental conditions was established. In addition to the lubricant study, parallel investigations were conducted on gear materials and methods of dispensing powder lubricants. Significant achievements of this program are listed below: 1. A pair of 5 DP spur gears, manufactured from M-50 tool steel, had operated for 98-1/2 hours at a speed of 7400 rpm, load of 1000 pounds per linear inch of tooth face, and temperature cycled from room temperature to 900° F. 2. Evaluations of fine-pitch (12/14 DP) superalloy and tool-alloy steel gears were conducted at speeds to 15,500 rpm, temperatures in excess of 1000° F, and loads to 1000 pounds per linear inch of tooth face. 3. All high-temperature evaluations performed during this program used a graphite plus cadmium oxide powder mixture as the gear lubricant. An air carrier was used to deliver the powder to the gear set. Author

**N65-26712** Fabriques d' Assortiments Reunies, Le Locle (Switzerland) Laboratoire de Recherches Appliquées.

**ACTUAL STATE OF OUR RESEARCH EFFORTS FOR AN IMPROVED LEVER ESCAPEMENT [ETAT ACTUEL DE NOS RECHERCHES POUR L'AMELIORATION DE L'ECHAPPEMENT A ANCRE]**

E. Favre and A. Simon-Vermot *In Soc. Suisse de Chronométrie Intern. Conf. on Chronometry, Vol. 2* [1964] p 701-712 *In FRENCH; ENGLISH and GERMAN summaries* (See N65-26708 16-14)

After a few remarks on the difficulties and disadvantages of the present escapement lubrication method, we shall mention two directions taken by the research done in this field. New materials will be discussed, which promise to overcome some of the present drawbacks of show other interesting properties. Among others, ceramic materials will be considered and their composition and properties compared to those of ruby and spinel. A new method of lubrication will be shown, which, as borne out by the results of several experiments, is directly adaptable to the classic materials, steel-ruby and brass-spinel. Author

**N65-26724** Societe Suisse de Chronometrie, Neuchâtel (Switzerland).  
**MATERIALS [MATERIAUX]**

J. P. Renaud *In its Intern. Conf. on Chronometry, Vol. 2* [1964] p 857-880 refs *In FRENCH; ENGLISH and GERMAN summaries* (See N65-26708 16-14)

The progress achieved during the five or six years concerning the choice of basic materials used in the manufacture of movements and assembly processes is reviewed. Only spirals, spring-boxes and springs are ignored, since they are the subject of a paper by Dr. S. Steinemann. A first part of the paper is devoted to basic materials used in the manufacture of the movement, of the watch-face, and of the glass. A second part touches on the problem of decorative and anticorrosive coatings, rust-proof treatment and passivation films. Finally, a third part establishes the progress achieved in the field of lubrication, oils, greases, solid lubricants, self lubricating materials, and anti-wear coatings. In each case, the industrial application is first discussed, then certain possible developments at a laboratory level which have a potential application to watch manufacture. It concludes with certain indications on the direction of new scientific and technical developments, as well as on problems not yet solved. Author

**N65-27111#** Naval Research Lab., Washington, D. C. Metallurgy Div.

**MARINE CORROSION STUDIES: DEEP OCEAN TECHNOLOGY. STRESS CORROSION CRACKING. CATHODIC PROTECTION** Second Interim Progress Report

B. F. Brown, T. J. Lennox, Jr., ed., R. L. Newbegin, M. H. Peterson, J. A. Smith et al Nov. 1964 51 p ref  
(NRL-1574; AD-610551)

Precracked cantilever stress-corrosion cracking tests on notched and fatigued specimens of high strength steels showed an increase of stress intensity from about 15% of the breaking strength of a dry precracked bar of steel having a yield strength of 200 ksi to about 65% for the same steel after heat treatment to a yield strength of 125 ksi. Corrosion caused by sea-water was found on stainless steel heat exchangers and on bare 5086-H32 aluminum alloy. The alloy corrosion was accelerated by coupling with noble metals. Also reported are studies on the effect of: cathodic protection on crevice and pitting corrosion of stainless steel; current distribution along a wire rope cathode; cathodic protection of wire rope; pressure on a steel cathode in a sodium chloride solution; and an aluminum anode cathodic protection for a Coast Guard vessel. G.G.

**N65-27271\*#** General Electric Co., Cincinnati, Ohio. Missile and Space Div.

**STUDIES OF ALKALI METAL CORROSION ON MATERIALS FOR ADVANCED SPACE POWER SYSTEMS. Quarterly Progress Report No. 3, Dec. 26, 1964-Mar. 26, 1965**

R. W. Harrison [1965] 30 p refs

(Contract NAS3-6012)

(NASA-CR-54390) CFSTI: HC \$2.00/MF \$0.50 CSCL 20F

The influence of stress on the corrosion behavior of an advanced refractory alloy in potassium, and the corrosion mass transfer effects in a stainless steel-columbium alloy potassium system are investigated. The potassium was transferred directly to an alloy reflux capsule from the final hot trapping container, and the capsule was sealed by electron beam welding in a vacuum of  $7 \times 10^{-6}$  torr. The results showed the oxygen in the potassium taken from the fill tube to be 5 ppm, and the oxygen in the potassium taken from the chamber samples to be 8 ppm. The stainless steel capsules were opened in an argon atmosphere and drained of potassium. After removal of the Cb-12r alloy sheet specimens, the capsules and specimens were cleaned and examined. No appreciable differences in appearance of the internal surfaces of any of the capsules were noted from visual observation. R.W.H.

**N65-27392\*** # National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**EFFECT OF SPEED, LOAD, AND TEMPERATURE ON MINIMUM-OIL-FLOW REQUIREMENTS OF 30- AND 75-MILLIMETER-BORE BALL BEARINGS**

Zolton N. Nemeth and William J. Anderson Washington, NASA, Jul 1965 17 p refs

(NASA-TN-D-2908) CFSTI HC \$1.00/MF \$0.50 CSCL 131

Minimum-oil-flow tests were conducted with 30-millimeter-bore, deep-groove ball bearings over a DN range (product of bearing bore in mm and shaft speed in rpm) of  $0.825 \times 10^6$  to  $0.975 \times 10^6$  and a temperature range of 170° to 400° F at a thrust load of 265 pounds with naphthenic-mineral-oil-air mist lubrication. Minimum required oil flow for continuous operation increased with increasing DN and bearing temperature. This increase agreed with previously published data for 75-millimeter-bore bearings. A generalized correlation of the data obtained herein and with the 75-millimeter-bore bearing indicates that minimum required oil flow can be expressed as a single function of bore size, load, DN, and bearing temperature. The correlation was developed for 30- and 75-millimeter-bore bearings at thrust loads of 265 to 3000 pounds, DN values of  $0.6 \times 10^6$  to  $0.975 \times 10^6$ , and temperatures of 225° to 500° F. Airflow, which was controlled independently of oil flow, was found to affect the minimum required oil flow at specific operating conditions. Airflow apparently affects the efficiency with which the bearing can utilize the oil droplets fed to it, and there appears to be an optimum mist velocity for a given DN or rotative speed. Author

**N65-27394\*** # Thompson Ramo Wooldridge, Inc., Cleveland, Ohio

**OPERATION OF A FORCED CIRCULATION, HAYNES ALLOY NO. 25, MERCURY LOOP TO STUDY CORROSION PRODUCT SEPARATION TECHNIQUES**

David B. Cooper Washington, NASA, Jul 1965 73 p refs

(Contract NAS5-462)

(NASA-CR-241) CFSTI HC \$3.00/MF \$0.75 CSCL 18G

A Haynes alloy No. 25, forced circulation, mercury loop was designed and operated for a total of 5218 hours at an average boiling temperature of 1097° F. Corrosion product separators were included in both the vapor and liquid sections of the system and were evaluated for their effectiveness in reducing problems associated with mass transfer in mercury systems. The vapor corrosion product separator was approximately 51 percent efficient in removing corrosion products carried over from the boiler. Operation of this loop for 5218 hours has demonstrated the feasibility of long-term operation of a Haynes alloy No. 25 mercury system. Author

**N65-27510 Boeing Scientific Research Labs., Seattle, Wash. BOUNDARY LAYERS**

F. D. Hains *In its Rev. of Magnetofluidyn. Appl.* Apr. 1965 p 117-130 refs (See N65-27505 16-25)

A discussion is given on the use of magnetofluidynamic boundary layers in liquid metal bearings. A review of the various types of magnetofluidynamic bearings is presented. The possible use of magnetic fields to reduce the convective heat transfer at the nose of reentry bodies is discussed and a review of the reentry problem is given. N.E.A.

**N65-27786# Southwest Research Inst., San Antonio, Tex. Dept. of Aerospace Propulsion Research FUNDAMENTAL INVESTIGATION OF LIQUID-METAL LUBRICATED JOURNAL BEARINGS Topical Report, Apr. 1, 1964-through Mar. 31, 1965**

R. A. Burton, H. J. Carper, and Y. C. Hsu 16 Apr. 1965 110 p refs

(Contract AT(11-1)-1228)  
(SwRI-1228-60)

A program is reported with the objective of providing basic information for liquid-metal lubricated bearings with emphasis on turbulence and film-inertia effects. The experiments make use of a large-scale bearing model, with 6-foot diameter and 0.5 in film thickness. The working fluid is air, and Reynolds numbers comparable to those in liquid-metal lubricated bearings may be simulated. Data on velocity profiles, friction coefficients, and turbulence intensity are reported for concentric and eccentric operation. Data are also reported for extremely distorted flows produced by placing a blockage in the film. An analytical approach is reported, which exploits experimentally measured (or theoretically computed) profile parameters to predict pressures in bearing configurations. Data are given which show that inertial effects at the boundaries of the bearing film may at times be of primary importance in bearing calculations. Author

**N65-27803# Du Pont de Nemours (E.I.) and Co., Wilmington, Del. Engineering Materials Lab**

**THE SLIDING OF PTFE ON PTFE Technical Documentary Report, Feb. 15-Aug. 15, 1964**

R. P. Steijn Wright-Patterson AFB, Ohio, AF Mater Lab, Dec. 1964 32 p refs

(Contract AF 33(615)-1201)

(ML-TDR-64-303; AD-610585)

In sliding tests, a weighted sled with PTFE runners was pulled over a PTFE track. The sliding velocity was measured as a function of tangential load and ambient temperature for two normal loads. The results have led to treating the sliding phenomenon as an activated viscous-flow process relating sliding speed to force of friction and absolute temperature. An activation energy of about 7 kcal/mole was found. The size of the kinetic unit was estimated. Electron microscopy was used to examine the sliding surfaces; very thin films of PTFE were extracted during replication. We hold shear in these films and their deformation responsible for the viscous sliding behavior. The effect of the crystalline transitions at 19° and 30° C was investigated. Time effects were noted throughout the entire test program and documented. Author

**N65-27856# Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.**

**SYNTHETIC OILS FOR TURBINE ENGINES**

Boleslaw Mielnikowa 8 Dec. 1964 18 p refs Transl. into ENGLISH from Tech. Lotnicza (Poland), no. 2, 1963 p 37-42 (FTD-TT-64-117/1+2; AD-455605)

The requirement for better lubricants by high-speed aircraft is discussed and the synthetic lubricants used by various countries are briefly reviewed. Among the synthetic lubricants discussed are the esters of the mono and polybasic alcohols and organic dicarboxylic acids, esters of silicic acid and higher monobasic alcohols, and the silicones. It is observed that dicarboxylic acid esters are the most suitable lubricants for turbo engines. Data are given for commercial lubricants available for turbine engine and aviation lubrication. E. E. B.

**N65-27911# Monsanto Research Corp., Dayton, Ohio DEVELOPMENT OF FIRE-RESISTANT WATER BASE HYDRAULIC FLUID Bimonthly Report, 1 Dec. 1964-31 Jan. 1965**

E. S. Blake, G. F. Deebel, and G. A. Richardson [1965] 17 p (Contract NObs-90270)  
(BMR-5; AD-610674)

The broad objective of this contract is the development of a usable, fire-resistant water-base hydraulic fluid for shipboard use, in which the nonaqueous phase is fire-resistant. The alkali alkyl phosphates continue to afford the optimum properties as pour point depressant candidates. Introduction of a phenyl moiety into the ethyl group raised the AIT to 900° F. Of the commercially available thickeners tested, Cellosize hydroxyethyl cellulose (WP4400) and WSR 205 were of interest as

thickeners. The low percentages suggest that from a shear stability standpoint they may be suspect. The AIT of phosphates appears unaffected by large amounts of water. Author

**N65-27926#** Houghton (E. F.) and Co., Philadelphia, Pa.  
**DEVELOPMENT OF FIRE RESISTANT WATER BASED HYDRAULIC FLUIDS** Bimonthly Report

Philip Rakoff, G. John Colucci, and Robert K. Smith 27 Jan. 1965 18 p  
 (Contract NObs-90269)  
 (BMR-5; AD-610379)

Improving the corrosion properties of fire resistant, water based hydraulic fluid, a series of hydroxy alkylene carboxylates have been prepared as potential corrosion inhibitors. In addition, a continuing study has been made of the correlation existing between corrosion of control panels in hydraulic systems and bench corrosion tests. Several aromatic ether derivatives are concurrently being evaluated as autoignition improvers. An attempt has also been made to alter the structure of the glycol portion of fluid so that a higher autoignition temperature is attained in the finished formula. Author

**N65-28052** Joint Publications Research Service, Washington, D. C.

**ON THE STABILITY OF THE MOTION OF A GYROSCOPE ON A HORIZONTAL PLANE UNDER THE ACTION OF DRY SLIDING FRICTION**

I. M. Mindlin *In its Eng. J.* 29 Jun. 1965 p 12-20 refs (See N65-28050 17-23) CFSTI: \$6.00

Presented is a theoretical study on the stability of the stationary motion of a symmetric heavy gyro on a fixed horizontal plane in which its axis remains spinning. It is assumed that sliding is possible at the point of contact of the gyro with the plane, and that a dry friction force is developed. Considered is the action of viscous friction, and the motion of a top with the appearance of dry sliding friction which slightly deflects the top from the stationary motion present with movement over a smooth surface. Using expressions for the energy of two integrals known for the spherical surface, the validity of the stability condition is demonstrated. S.C.W.

**N65-28108#** Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.

**PETROLEUM SPECIALIST Selected Articles**

19 Jan. 1965 5 p Transl. into ENGLISH from Neftyanik (USSR), v. 4, no. 12, 1959 p 27  
 (FTD-TT-64-778/1; AD-610794)

**CONTENTS:**

1. ADDITIVE TO HEAVY HIGHLY SULFUROUS ENGINE FUELS T. Skichko p 1
2. ANTICORROSION ADDITIVE TO LUBRICANTS T. Skichko p 2

**N65-28141#** Oak Ridge National Lab., Tenn.

**THE EFFECT OF OXYGEN ON THE CORROSION OF NIOBIUM BY LIQUID POTASSIUM**

Arnold Powell Litman (M.S. Thesis-Tennessee Univ.) Jul. 1965 121 p refs  
 (Contract W-7405-ENG-26)  
 (ORNL-3751) CFSTI: \$4.00

The behavior of niobium in liquid potassium at 200°, 600°, and 815° C was influenced by oxygen, temperature, and time. The corrosion manifestations include the production of surface and subsurface corrosion products and the mass transfer of oxygen, niobium, and potassium. Analysis of the surface scales indicated they were predominantly niobium dioxide, but that niobium metal, niobium oxide, and potassium metaniobate were present. Hardness profiles of the specimens as a

function of time confirmed that a loss of oxygen from the niobium occurred by solid state diffusion at 600° and 815° C but that no loss occurred at 200° C. Oxygen migrated out of niobium even when niobium dioxide was found in the surface and subsurface scales. Niobium dioxide was found to be unstable in excess potassium. These observations led to the proposal that one or more ternary compounds provide the driving force for system corrosion. These compounds have sufficient thermodynamic stability to reduce the chemical potential of the oxygen in solution below that which exists for equilibrium with binary oxides. R.N.A.

**N65-28191#** Air Force Systems Command, Wright-Patterson AFB, Ohio, Foreign Technology Div.

**MECHANISM OF THE ACTION OF VISCOUS ADDITIVES**  
 Ye. G. Semenidov 27 Apr. 1965 9 p refs Transl. into ENGLISH from Neftyanoye Khozyaystvo (USSR), v. 32, no. 3, 1954 p 38-41

(FTD-TT-64-1274/1+2; AD-615247)

The viscosity index  $v_{50}/v_{100}$  for evaluating the viscotemperature properties of thickened oils is shown to be useful in the temperature interval range of -30° to 50° C, in addition to its usefulness in the interval from 50° - 100° C. Viscotemperature data show that (1) of two oils with identical viscosity at 100° C, the oil with the lower index for  $v_{50}/v_{100}$  has the better viscotemperature properties; and (2) of two oils with the same index of  $v_{50}/v_{100}$ , the oil with less viscosity has the better viscotemperature properties. Thus the thickening action of polymers, the index  $v_{50}/v_{100}$  of the oil base, and the viscotemperature properties of thickened oils are interdependent, even in the negative temperature region. The mechanisms of polymers added as viscous additives to oils are also considered, by analyzing how the relationship of the viscosity of oil thickened by polymers ( $v$ ) to the viscosity of an oil base ( $v_0$ ) changes with identical temperatures over a broad range. From tabulated data on values of  $v/v_0$  for oils thickened with polyisobutylene, it appears that in mixing oils with polymers, the viscosity level is raised, and the character of the temperature change remains the same, or deteriorates somewhat with increased polymer content. L.S.

**N65-28201\*#** Southern Research Inst., Birmingham, Ala.

**EFFECT OF PROTECTIVE COATINGS ON THE STRESS-CORROSION PROPERTIES OF SUPERSONIC-TRANSPORT SKIN MATERIALS** Tenth Quarterly Status Report, 1 Mar.-31 May 1963

J. O. Honeycutt and A. C. Wilhelm 15 June 1965 27 p refs (Contract NASr-117)  
 (NASA-CR-63784) CSCL 11F

Steel, superalloy, and titanium alloy substrates, coated with aluminum-modified silicone, catalytically cured silicone, zinc in silicate vehicle, electrophoretically deposited aluminum, and flame-sprayed aluminum, were visually examined after undergoing exposures to dry 550° and humid 95° F atmospheres for 1000 hours. Four exposure conditions were used for each substrate coating combination: undamaged with no salt, and with salt; and damaged with no salt, and with salt. The specimens were then subjected to compressive loading for bend-ductility evaluations, with compression continued until fracture occurred, or complete compression was attained. The inherent ductility of a substrate was determined by measuring the shortening that occurred during compression of a bare, unexposed specimen. Results, which showed wide variation for the several specimens, are presented in tabular form and interpreted graphically. M.G.J.

**N65-28269** Joint Publications Research Service, Washington, D. C.

**INVESTIGATION OF ONE METHOD OF COMPENSATING FOR FRICTION IN SUPPORTS OF INSTRUMENT SHAFTS**  
B. A. Komashinskiy *In its Izv. VUZov: Instr. Bldg.* 9 Jul. 1965 p 134-139 refs (See N65-28250 17-10) CFSTI: \$5.00

Described is a method for reducing mechanical losses in instrument supports caused by friction, which focuses on the use of forced rotation on the outer races of ball bearings in the supports of instrument shafts. The selection of a speed of rotation is substantiated, and examples are cited which illustrate the effectiveness of the method. S. C. W.

**N65-28276#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PLASTICS AND RUBBER Selected Articles**

29 Apr. 1965 25 p refs Transl. into ENGLISH from *Plastics und Kautschuk* (Leipzig), v. 11, no. 1, 1964 p 36-42 (FTD-TT-64-1324/1+2; AD-463087)

**CONTENTS:**

1. THE INFLUENCE OF THE THERMAL AFTER-TREATMENT ON THE PROPERTIES OF POLYAMIDE COATINGS  
Z. Kowalski p 1-12 refs (See N65-28277 17-18)

2. PLASTICS FOR FLAME SPRAYING AND THEIR CHARACTERISTICS  
H. Schwarz p 13-26 refs (See N65-28278 17-18)

**N65-28277** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE INFLUENCE OF THE THERMAL AFTER-TREATMENT ON THE PROPERTIES OF POLYAMIDE COATINGS**

Z. Kowalski *In its Plastics and Rubber* 29 Apr. 1965 p 1-12 refs Presented at the Intern. Metal, Plastic, and Ceramic Spray Conf., Halle (Saale), 10-12 Sep. 1963 (See N65-28276 17-18)

Poly undecanamide (polyamide 11) and poly caprolactum (polyamide 6) coating materials were applied to test specimens, which were then subjected to various after-treatments for determining the influence of each treatment on the structural properties of the coatings. Some of the after-treatments used were soaking and tempering in paraffin oil or water baths at differing temperature levels. Specimens were also subjected to infrared radiation, and oxygen. Various bending strength and impact resistance tests were applied after the treatments. It was shown that the characteristics of polyamide coatings can be materially changed by the influence of heat (positively and negatively), and do afford some protection from the influence of oxygen at high temperatures. The method of coating the specimen is also important, and coatings applied by turbulent sintering are more resistant to impact-type stresses than those that are flame sprayed. Polyamide 11 coatings were found superior to polyamide 6 coatings not only with regard to their natural properties, but also with regard to their impact resistance. Test data and physical property data of test materials are included. L.S.

**N65-28351#** Frankford Arsenal, Philadelphia, Pa. Pitman-Dunn Research Labs.

**STRESS-CORROSION TESTS ON COMMERCIAL AND HIGH PURITY GRADE 7075-T6 ALUMINUM ALLOY**

Helen R. Pritchard May 1965 14 p refs (M65-17-1; AD-615566)

Alternate immersion stress-corrosion tests were conducted on commercial and high purity 7075-T6 aluminum alloy stressed in the short transverse direction at levels of 8000 psi to yield strength. No failures occurred in the commercial grade at stress levels of 20,000 psi or less. In the high purity grade, the highest stress which did not produce failures was 10,000 psi. At levels of 30,000 psi or less, the commercial grade specimens had a life of three or more times that of the high purity specimens. Author

**N65-28354#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**MATERIALS FOR POTASSIUM LUBRICATED JOURNAL BEARINGS** Quarterly Progress Report No. 7, 22 Oct. 1964-22 Jan. 1965

R. G. Frank, ed. [1965] 139 p refs

(Contract NAS3-2534)

(NAS-CR-54345) CFSTI: HC \$4.00/MF \$1.00 CSCL 11F

Approximately 25 pounds of potassium were purified by hot trapping for 24 hours at 1200° to 1350° F in a titanium-lined zirconium-gettered hot trap after being purified by vacuum distillation. The vacuum distillation facility for the cleaning of the tested corrosion specimens was completed. Cb-12r alloy corrosion capsules were measured dimensionally and weighed. Lucalox and Zircoa 1027 exhibited the largest change in dimensions. To evaluate dimensional stability, duplicate specimens of candidate materials were tested at 800°, 1200°, and 1600° F. Zircoa 1027 showed a change of +0.03% at 800° F and the Star J alloy showed a change of +0.06% at 1600° F. The mean coefficient of thermal expansion was determined as a function of temperature from room temperature to 1600° F for K601, TiC, TiC+10%Cb, TiC+10%Mo, TiC+5%W, TiB<sub>2</sub>, and Star J. Excellent agreement of the data was observed between duplicate specimens and between heating and cooling cycles of the same material. The compression load train was checked out successfully at room temperature with Mo-TZM alloy specimens and the compressive 0.2% yield strength was 113,300 psi. R. N. A.

**N65-28504#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**FRICTION COEFFICIENTS OF MATERIALS FOR GUIDE MACHINES**

G. B. Lur'ye 19 Apr. 1965 10 p Transl. into ENGLISH from *Stanki i Instrument* (USSR), v. 30, no. 3, 1959 p 17-19 (FTD-TT-64-1179/1+2; AD-615229)

Experiments were conducted to determine friction in slide guides, operating at feeding rates. A comparative evaluation was made of the antifriction properties of numerous materials used for strap guides. Values were derived of friction coefficients in dependence upon the duration of the stationary contact and sliding speed. Materials tested during friction along the cast iron included: metals (cast iron SCH 2-40, bronze Br. OTSS 6-6-3, babbitt B16, zinc alloys TSAM 30-4 and TSAM 10-5); plastics (metallurgical Textolite B, polyamide resin 68 of Nylon type, textolite PT, cordovoloknite 1-G, vinyl plastics, fluoro plastic-4) and graphite coated materials (ferro-graphite, anticorrosion heat conductive ATM material, bronze-graphite, graphite coated material type D, lead saturated).

Author

**N65-28624#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**METHOD OF IMPROVING THE ANTIWEAR PROPERTIES OF LUBRICATING OILS**

V. S. Demchenko, Ye. N. Gur'yanova, and O. I. Bogdanova 19 Apr. 1965 4 p Transl. into ENGLISH from Russian Patent No. 158038 (Appl. No. 783882/23-4, 23 Jun. 1962) 2 p (FTD-TT-64-1287/1; AD-615250)

The object of the invention is a method improving the antiwear properties of lubricating oils which is distinguished by the fact that as additives one introduces derivatives of 2-mercaptobenzthiazole, for example, benzthiazole-2-cyclohexylsulfenamid.

Author

**N65-28697#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**AT THE TECHNICAL-ECONOMICAL COUNCIL OF THE LENINGRAD SOVNARKHOZ**

Ya. K. Terent'yev, 23 Apr. 1965 5 p Transl. into ENGLISH from Byull. Tekh.-Ekon. Informatsii (Moscow), no. 2, 1964 p 76-77  
(FTD-TT-64-1242/1; AD-615288)

Information regarding the use of molybdenum disulfide as an antifriction coating was reported to the technological section of machine construction of the technical-economical soviet of the Leningrad Sovnarkhoz (Council of National Economy). The use of molybdenum disulfide is reported to increase, by an average of 2 to 3 times, the stability of cutting tools and dies.

Author

**N65-28723#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**METHOD OF PRODUCING NONFLAMMABLE LUBRICANTS FOR TURBINES**

K. I. Ivanov, Ye. D. Vilyanskaya, and L. N. Kirichenko 28 Apr. 1965 5 p Transl into ENGLISH from Soviet Patent No. 159922 (Appl. No. 807683/23-4, 13 Dec. 1962) 2 p  
(FTD-TT-64-1291/1; AD-615297)

The object of the invention is a method of obtaining a fire-resistant liquid for turbines on the basis of compounds containing phosphorus with additives. To improve the quality of the product and reduce its cost, trixylinylphosphate is used as the phosphorus compound, perfluorinated transformer oil as an antifoaming additive and 4,4(1)-diamino-diphenyl-disulfide as an antioxidant.

Author

**N65-28845#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**NATURE OF POLYSILOXANES AND ITS EFFECT ON THEIR ACTION AS ADMIXTURES TO HYDROCARBON LUBRICATING AGENTS**

G. V. Vinogradov, N. S. Nametkin, and M. I. Nosov 26 Apr. 1965 10 p refs Transl into ENGLISH from Neftekhimiya (USSR), v. 4, no. 2, 1964 p 345-350  
(FTD-TT-64-1268//1+2; AD-615245)

To explain the effect of the nature of polysiloxanes on the improvement of the lubricating effect of hydrocarbons during their addition into same, the antiwear and antifriction properties of mixtures of 1,1-di(o-xylyl)-ethane with polyethylsiloxane, polymethylsiloxane and two polymethylphenylsiloxane liquids were investigated. Mutual strengthening of the lubricating effect of polysiloxanes and hydrocarbons depends to a large degree upon the nature of polysiloxanes, which by degree of reducing their activity as admixtures, improving the lubricating qualities of hydrocarbons, are arranged in the following series: Polyethylsiloxane > polymethylsiloxane > polymer 1 > polymer 2. An assumption was made that this is connected with a rise in thermooxidizing stability during the change in polysiloxane chains of ethyl side groups into methyl and phenyl. Mutual strengthening of the lubricating effect of hydrocarbons and polysiloxanes may appear not only then when they are soluble in each other but also when they are emulsified in hydrocarbon media.

Author

**N65-29112#** Aluminum Co. of America, New Kensington, Pa. Chemical Metallurgy Div.  
**INVESTIGATION OF THE MECHANISM OF STRESS CORROSION OF ALUMINUM ALLOYS** Final Report, Dec. 6, 1963-Feb. 6, 1965

G. C. English [1965] 105 p refs  
(Contract NOW-64-0170-c)  
(AD-615789)

The cathodic protection of 7075 alloy in a corrosive, acid chloride solution was investigated. Subsize tensile specimens for protection were taken in the short-transverse direction from 2-inch thick plate in two tempers, one (-T6) susceptible to stress corrosion and one (-T73) not susceptible to this type

of corrosion. In the solution used a susceptible specimen stressed to 75% of its yield strength failed by stress corrosion in an hour while a stresses nonsusceptible specimen failed by general corrosion within two days. At a potential 0.57 volts negative to the free corrosion potential, a stressed susceptible specimen could be protected for an indefinitely long period, one susceptible specimen stressed to 75% of its yield strength and held at this potential for 400 hours showed no evidence of stress corrosion. This potential of cathodic protection appeared to be independent of the stress applied to a specimen. Considerable evidence indicates that the potential reflected metallurgical structure rather than extraneous conditions such as the alkalinity produced by cathodic reactions.

Author

**N65-29121#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**EFFECT OF TEMPERATURE ON FRICTION AND WEAR OF FILLED FLUORINATED PLASTIC MATERIALS**

V. D. Parkhomenko and S. N. Gants 19 Apr. 1965 6 p refs Transl. into ENGLISH from Izv. Vysshikh Uchebn. Zavedenii, Mashinostro. (Moscow), no. 9, 1963 p 130-133  
(FTD TT 64 1176/1+2; AD-614957)

An examination was made of the effect of temperature and the nature of the filler (molybdenum disulfide, boron nitride, barium sulfate, ground coke, talc, soot, or colloidal graphite) on the coefficient of friction and wear of 'Fluoroplast' (poly(chlorotrifluoro ethylene)) while undergoing a water-lubricated friction process. In general: (1) wear decreases with increasing filler content (up to a limit); (2) wear increases with increasing water temperature; (3) the coefficient of friction ( $\mu$ ) increases as temperature increases; (4)  $\mu$  decreases with increasing specific pressure; and (5)  $\mu$  decreases with increasing speed of sliding. Under the test conditions MoS<sub>2</sub>, BN, BaSO<sub>4</sub>, and coke improved the wear resistance to a greater extent than the other fillers.

TAB

**N65-29234#** Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.  
**CORROSION OF EQUIPMENT IN THE HEAVY WATER COMPONENTS TEST REACTOR**

J. Malvyn Mc Kibben Jun. 1965 32 p refs  
(Contract AT(07-2)-1)  
(DP-964) CFSTI: \$2.00

The corrosion experience at the Heavy Water Components Test Reactor (HWCTR) is evaluated after three years of service. Within the moderator-coolant system, corrosion caused no operating problems or equipment failures. Adherent black oxide covered all mild steel surfaces in the moderator-coolant system, and no significant pitting was observed.

Author

**N65-29446\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**CORROSION IN LIQUID METAL SYSTEMS**

D. H. Gurinsky, J. R. Weeks, C. J. Klamut (Brookhaven Natl. Lab.), L. Rosenblum, and J. H. De Van (Oak Ridge Natl. Lab.) [1964] 15 p refs

(NASA-TM-X-54722) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

Current theories of liquid metal corrosion, methods employed in liquid metal testing and analysis, and the state of the art of each of the alkali metals, Hg, and liquid alloys containing Pu are reviewed. Liquid metal materials were developed and tested for higher temperature applications. Engineering tests to determine the long term behavior of containment alloys for sodium components show that the 650°C temperature range is feasible. In nuclear auxiliary power systems, refractory alloys show promise for the containment of liquid Li and are also suitable for power conversion systems using boiling K, Na, Rb, Cs, and Hg. Confirmation of the importance of impurities in the liquid metals and the containment alloys on

the corrosion process resulted in advances in testing and analytical techniques. Although the precision of impurity analyses and the monitoring techniques of the liquid metals have been improved, accuracy remains uncertain because of the lack of calibration standards. The use of X-ray fluorescence and microprobe techniques has delineated the subtle surface effects due to corrosion. R.N.A.

**N65-29643#** Royal Aircraft Establishment, Farnborough (England).

**THE REDUCTION OF FRICTION IN PISTON TYPE HYDRAULIC SERVO VALVES**

A. G. Earl. London, Min. of Supply, May 1954. 14 p refs (RAE-TN-GW-312)

This note describes experiments that have been made to investigate the effectiveness of two methods of reducing friction in piston type hydraulic servo valves. The methods tried were very fine filtration of the oil supply and tapering the sealing lands of the servo piston. The first of these gave a reduction in valve friction of about 80% and the second method a reduction of about 60%. A combination of the two resulted in a decrease in friction of over 90%. Author

**N65-29738\*#** National Aeronautics and Space Administration, Washington, D. C.

**SPONTANEOUS TRANSITION OF SLIDING FRICTION TO ROLLING FRICTION IN THE HIGH-TEMPERATURE TESTING OF REFRACTORY CARBIDES [SPONTANNYY PEREKHOD TRENIYA SKOL'ZHENIYA V TRENIYE KACHENIYA PRI VYSOKOTEMPERATURNYKH ISPYTANIYAKH TUGOPLAVIKH KARBIDOV]**

A. P. Semenov and V. V. Pozdnyakov. Jul. 1965. 9 p. ref. Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 160, no. 5, 1965 p. 1057-1060 (NASA-TT-F-9499) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F.

Two specimens, both of vanadium or molybdenum carbide, were friction tested by being made to rub together in vacuum with simultaneous heating and subsequent cooling. When heated, the specimens manifested a decrease in mean friction coefficient, in one case from 0.6 to 0.3, then the onset of oscillations in the friction coefficient with a sharp rise in friction coefficient (to 0.85), and, finally, the spontaneous transition from sliding to rolling friction with a concomitant drop in the mean friction coefficient to 0.05. The effect is explained by a surface-geometric mechanism, whereby the surfaces in contact crumble at high temperature, ejecting balls of the tested material, which fit into pits or grooves and act as roller bearings. Author

**N65-29845\*#** National Aeronautics and Space Administration, Washington, D. C.

**LUBRICATION, CORROSION AND WEAR A Continuing Bibliography, Jan. 1962-Mar. 1965**

[1965] 167 p refs (NASA-SP-7020) CFSTI: HC \$1.75/MF \$1.00 CSCL 11H

An annotated bibliography is presented on lubrication, corrosion, and wear. Included are topics such as lubricating systems, design and performance of bearings, special applications of lubricants, stress corrosion and fatigue cracking in metals and alloys, friction and wear characteristics of materials, and types of corrosion and techniques for corrosion prevention. A few references describing the instrumentation and methods of testing lubricants are also included. R.N.A.

**N65-29914#** Battelle Memorial Inst., Columbus, Ohio. Defense Metals Information Center.

**CORROSION OF MATERIALS BY ETHYLENE GLYCOL-WATER**

J. D. Jackson, P. D. Miller, F. W. Fink, and W. K. Boyd. 10 May 1965. 25 p refs

(Contract AF 33(615)-1121)

(DMIC-216; AD-466284)

Solutions of ethylene glycol are being considered as heat-transfer media for radiators in manned space capsules. This report was prepared to summarize the available corrosion data on uninhibited and inhibited ethylene glycol solutions. Much of the corrosion data are based on automotive and diesel engine coolant systems. Several factors considered are: time dependence, effect of pH, concentration, temperature, aeration, chloride ion, velocity, heat-transfer rate, and galvanic couples. Inhibitors for which corrosion data are presented include: borax, sodium benzoate, sodium nitrite, triethanolamine, sodium mercaptobenzothiazole, soluble oil, chromates, as well as miscellaneous inhibitors. A number of patented inhibitors based on borax are discussed. Descriptions of test procedures including automobile service tests are presented. Author

**N65-29941#** Naval Postgraduate School, Monterey, Calif.  
**AN INVESTIGATION OF THE WEAR AND FRICTION CHARACTERISTICS OF A HIGH TEMPERATURE SOLID FILM LUBRICANT IN HIGH VACUUM AND IN AIR**

Donald W. Flage (M.S. Thesis) 1964. 128 p refs

With a specially designed machine, the wear and friction characteristics of high temperature SFL #1000 were investigated. The lower wear specimen, coated at the factory to a thickness of 0.0003 to 0.0005 in., was the rotating member. The upper non-rotating specimen, identical to the lower, was uncoated. These mating wear and friction annular surfaces were tested under controlled variables. The SFL #1000 ceramic bonded high temperature solid film lubricant was found to have: (1) unacceptably high dynamic coefficient of friction in high vacuum as well as in air. Typical values ranged from 0.30 to 0.40; (2) undesirable stick-slip phenomenon, occurring when the static friction coefficient exceeds the dynamic coefficient; (3) excessively high wear rates (typical rates ranged from 10 to 50  $\mu\text{in.}/\text{min.}$ ); and (4) low lives. Film failure occurred usually between 1 and 10 minutes. The results of these tests clearly indicated that this lubricant would make a poor candidate for any practical engineering application where moderate speed and running time were needed. N.E.A.

**N65-30004#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**NEW ADDITIVES TO FUELS AND LUBRICANTS**

Ya. B. Chertkov. 14 May 1965. 10 p refs. Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), v. 7, no. 3, 1962 p. 64-66

(FTD-TT-65-62/1; AD-616312)

A review of Western literature dealing with fuel and lubricant additive developments is presented. Antioxidants for gasoline and other petroleum products, multifunctional additives, polymerization, and copolymer additives are among the topics considered; and the characteristics for a fuel-oil additive are given. M.W.R.

**N65-30014#** Rock Island Arsenal Lab., Ill.  
**CORROSION RESISTANCE OF BLACK OXIDE COATINGS ON MILD AND CORROSION RESISTANT STEELS**

Linden H. Wagner. 21 Dec. 1964. 23 p refs

(RIA-64-3580; AD-615941)

In the revision of Military Specification MIL-C-13924A, dated 29 December 1956, the various processes were reviewed and evaluated for their effectiveness in blackening mild steel, 300 and 400 corrosion resistant steels. The corrosion resistance of these coatings were also investigated. A low temperature Class 4 proprietary alkaline-oxidizing process was



proposed for blackening only the 300 series stainless steels in lieu of the fused salt oxidizing process which operates at 760° F.

Author

**N65-30048#** Air Force Systems Command, Wright-Patterson AFB, Ohio, Foreign Technology Div.  
**SYNTHESIS OF ANTICORROSION PIGMENT-CHROMIUM PHOSPHATE**

M. A. Shtern, N. Ye. Danyushevskaya, and O. V. Alekseyeva  
 14 May 1965 9 p refs Transl. into ENGLISH from *Lakokrashochnyye Materialy i Ikh Primeneniye* (Leningrad), no. 1, 1964 p 32-34

(FTD-TT-65-55/1+2; AD-616308)

Optimum conditions for synthesizing chromium phosphate for use as an anticorrosion pigment in phosphatization priming and single packing bases were investigated. The effect of chemical composition of chromium phosphate on its protective qualities was studied and the results tabulated. Tests also showed that the dispersion composition of the pigment exerted practically no effect on the anticorrosion properties of the sealer. The kinetics of the process of chromium reduction with sodium sulfite, and deposition of phosphate were investigated in the pH range from 1.0 to 4.5. It was found that the rate of chromium reduction and precipitation of chromium phosphate is affected by the temperature conditions of the synthesis. The optimum conditions are listed, and the investigations show that chromium phosphate, synthesized under these conditions appears to be a highly effective anticorrosion pigment which can be used for pigmentation of single packing sealers of VL-02 type.

M.R.W.

**N65-30505#** Battelle Memorial Inst., Columbus, Ohio.  
**A STUDY OF THE INFLUENCE OF LUBRICANTS ON HIGH-SPEED ROLLING-CONTACT BEARING PERFORMANCE. PART V: RESEARCH ON ELASTO-HYDRODYNAMIC LUBRICATION ON HIGH-SPEED ROLLING CONTACTS**  
**Final Report**

Jerrold Kannel, J. Clarence Bell, J. A. Walowit, O. A. Ullrich, and C. M. Allen Wright-Patterson AFB, Ohio, AF Aero Propulsion Lab., Jul. 1965 89 p refs  
 (Contract AF 33(615)-1311)

(ASD-TDR-61-643, Pt. V; AD-467173)

The effects of lubricants on the performance of heavily loaded rolling-contact elements have been studied experimentally and theoretically. Measurements of the deformations of lubricated rolling elements have been made using an X-ray technique for a range of loadings, temperatures, rolling speeds, and lubricants. A qualitative agreement appears to exist between variations in deformation profiles with lubricant types and variations in existing fatigue life with lubricant type. Efforts have been made to infer film pressures from the deformation measurements. Film pressures have been measured between steel as well as quartz disks using a manganin pressure transducer. For the heavily loaded conditions, a slight pressure spike appears in the measurements of pressures between steel disks. Stresses in the rolling elements have been inferred from the pressure measurements. The magnitudes of the maximum stresses do not deviate significantly from the Hertzian stresses although the location of the maximum shearing stress is much closer to the surface. The temperature on the surface of a pair of quartz disks has been measured using an evaporated resistance thermometer type transducer. The magnitude of the measured apparent temperature appears to be higher than anticipated resembling the peak temperature predicted assuming no heat loss from the lubricant to the disk for the pass of each fluid element through contact.

Author

**N65-30545\*#** IIT Research Inst., Chicago, Ill. Technology Center.

**INVESTIGATION OF SLIP-RING ASSEMBLIES** Quarterly Report No. 7, 5 Nov. 1964-5 Feb. 1965

J. L. Radnik [1965] 13 p

(Contract NAS8-5251)

(NASA-CR-64251; E6000-21) CFSTI: HC \$1.00/MF \$0.50 CSCL 131

Run-in tests were performed with experimental and commercial capsules to determine the effects of surface lubrication by a heavy layer of P-38 synthetic oil. Lubrication with a graphite oil mixture was also evaluated. Experimental capsules were fabricated to simulate the constructional features of commercial assemblies and to achieve the thermal isolation that exists between rings in an actual assembly. The effects of palladium additions to a gold plating bath were evaluated and a drive system for operation in a vacuum chamber was designed. Run-in tests demonstrated that destructive galling and erosion effects occur primarily in unlubricated systems which permit high localized temperatures. All unlubricated capsules containing isolated rings exhibited severe seizing or high friction effects leading to permanent damage of the rings and brushes. Surface lubrication with P-38 oil was effective in minimizing wear and noise levels in experimental and commercial capsules. Electrodeposits from rhodium and palladium modified gold baths did not exhibit any significant increase in plate hardness. In the case of rhodium, an actual decrease was obtained.

R.N.A.

**N65-30826#** Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.

**ADSORPTION AND FRICTION BEHAVIOR OF MINERALS IN VACUUM** Research in Earth Physics Phase Report No. 2

Leslie G. Bromwell Mar. 1965 96 p refs

(Contract DA-22-079-ENG-330; ARPA Order 400)

(R64-42; AD-616737)

This report presents theoretical considerations on the adsorption and friction behavior of soils under high vacuum and extreme temperature conditions. It includes an extensive literature survey, particularly in the fields of surface chemistry and physics, adsorption, and friction. The importance of using clean, reproducible surfaces for surface studies is demonstrated. The necessity of clean ultrahigh vacuum test conditions for producing and maintaining clean surfaces is emphasized. The relationship between atomic forces and surface energy and the friction and adhesion between solid surfaces is discussed. A theoretical relationship between adsorption energy and the temperature and pressure required to remove adsorbed layers is derived. The frictional behavior of quartz is considered in detail.

Author

**N65-30860#** Aerospace Medical Div. Aerospace Medical Research Labs. (6570th), Wright-Patterson AFB, Ohio. Biomedical Lab.

**MICROBIAL ACTIVITY IN AIR FORCE JET FUEL SYSTEMS** Technical Report, Feb. 1963-Apr. 1964

Sheldon A. London, Viola H. Finefrock, and Lawrence N. Killian (Systems Res. Labs.) Apr. 1965 31 p refs Prepared jointly with Systems Res. Labs., Inc.

(Contract AF 33(657)-11733)

(AMRL-TR-65-30; AD-616648)

Malfunctions and changes occurring in JP-4 fuel systems have been attributed to the presence of microorganisms. The known capability of microbial entities to utilize hydrocarbon products as a carbon source has been considered as a priori evidence of a direct cause-effect relationship in the deterioration of jet fuel systems. The direct implication of microbes in the deterioration of Air Force jet fuel systems has not been proved unequivocally. The U.S. Air Force, as well as the Navy and Army, have instituted research programs to determine the

specific changes caused by bacterial and fungal growth in JP-4 and the contributory factors which promote or retard their activities. The presence of contaminating microbes was shown to occur only in association with free water. Microbial corrosion of various aluminum alloys has been demonstrated in the laboratory, but poor reproducibility attests to the lack of understanding of this phenomenon. The efficacy of the anti-icing additive, ethylene glycol monomethyl ether (EGME), as a microbial inhibitor has been well documented. Although a low level of viable microorganisms continues to be observed in Air Force fuel systems, the application of good housekeeping and the effect of EGME appear to have controlled their activity.

Author

**N65-30867# Koppers Co., Inc., Monroeville, Pa.  
DEVELOPMENT OF HIGH TEMPERATURE SEAL-LUBRICANT DEPOSIT EVALUATION TECHNIQUES Technical Report, 1 Jan.-30 Nov. 1964**

Billy D. Pfoutz, William G. Knox, and Frank Gannon. Wright-Patterson AFB, Ohio, Aero Propulsion Lab., 3 May 1965 21 p (Contract AF 33(615)-1112) (AFAPL-TR-65-3; AD-617072)

Testing techniques for evaluating experimental gas turbine lubricants in face-riding main shaft jet engine seals at temperatures representative of high mach aircraft have been under development. Using the ASD Seal Rig, repeatable evaluation techniques were developed for MIL-L-9236 type lubricants that were indicative of performance in engines. The present phase of the program is directed towards refining evaluation equipment and preparing the rig for more advanced research work. During the period covered by this report, internal seal head air heating to 1160° F, preliminary evaluation studies using O-60-19 and O-60-18 lubricants and engineering features of a new seal head design were investigated. An adaptor to permit the use of the seal head with Erdco test equipment is being designed. Author

**N65-30915# United States Steel Corp., Monroeville, Pa.  
Applied Research Lab.**

**STRESS-CORROSION BEHAVIOR OF 12 PERCENT NICKEL MARAGING-STEEL WELDMENTS**

A. W. Loginow 31 Dec. 1964 20 p (Contract NObs-88540) (S-23309; AD-616982)

As part of the Applied Research Laboratory's program to determine the feasibility of developing an HY-180/210 weldment, studies were conducted to determine the stress-corrosion properties of 12Ni-5Cr-3Mo maraging-steel weldments in marine environments. Stress-corrosion tests were conducted with welded U-bend specimens in quiescent and flowing sea water, in the tidal zone, and in a marine atmosphere. Stress-corrosion cracking was observed in specimens exposed in the three seawater environments in 6 to 17 days; no significant difference in cracking time was observed among the environments. In the marine atmosphere the specimens showed an appreciably higher resistance to stress-corrosion cracking; the shortest cracking time in this environment was 62 days. Metallographic examination showed that, generally, the cracks initiated in the weld metal and propagated in the weld metal and in the heat-affected zone. The absence of base-metal cracking (away from welds) in some specimens exposed for 170 days is regarded as evidence that the base metal may be resistant to cracking in marine environments. It also appears that carbon steel can prevent cracking by cathodically protecting 12Ni-5Cr-3Mo weldments.

Author

**N65-30930# Automation Industries, Inc., Danbury, Conn.  
ULTRASONIC TECHNIQUES FOR FUEL TANK CORROSION EVALUATION Technical Report, Jun. 1964-Mar. 1965**

Emerson V. Briggs Wright-Patterson AFB, Ohio, Res. and Technol. Div., Apr. 1965 20 p (Contract AF 33(615)-1664) (RTD-TDR-63-4193, Pt. II; AD-467006)

This program provided for minor modifications to the Ultrasonic Inspection System to provide an improved capability to detect corrosion in the bottoms of integral fuel tanks on more types and sizes of aircraft than the equipment was originally intended for. The equipment was tested under actual service conditions in the field to determine its capabilities. Author

**N65-31051\*# SKF Industries, Inc., King of Prussia, Pa. Research Lab.**

**BEARING LUBRICANT ENDURANCE CHARACTERISTICS AT HIGH SPEEDS AND HIGH TEMPERATURES Progress Report No. 11, 1 Apr.-30 Jun. 1965**

G. Chiccarine, R. H. Pilkington, R. B. Evan, and C. J. Wachen-dorfer 20 Jul. 1965 63 p refs Revised (Contract NASw-492) (NASA-CR-64183; AL65T056) CFSTI: HC \$3.00/MF \$0.75

A bearing-lubricant combination consisting of a hydrocarbon lubricant with a proprietary lubricity additive, and M1 tool steel bearings having a smoother surface finish on the inner ring than on the outer ring was tested. Ten bearings tested at 600° F and 42,800 rpm ran for bearing lives of 300 to 700 million revs without any sign of failure, indicating an experimental  $L_{10}$  in excess of twice the AFBMA computed  $L_{10}$  life under the load and speed conditions used. Two modified polyphenyl ether lubricants, and a more viscous version have somewhat improved performance at temperatures of 500° to 600° F in a nitrogen atmosphere over the more conventional 5-ring polyphenyl ether, Skylube 600. The modified polyphenyl ethers tested in nitrogen atmosphere have about comparable performance to Skylube 600 tested in the air. Surface distress, cage failure, and smearing or gross metal transfer were identified as the three failure modes encountered in high-speed, high temperature, thrust-loaded bearings.

R W H

**N65-31073# Eidgenossische Technische Hochschule, Zurich (Switzerland)**

**THE GRAPHITIZATION OF CAST IRON [DIE GRAPHITIERUNG VON GUSSEISEN]**

Edward Fot (Ph D Thesis) 1964 36 p refs (Prom. 3549)

Electrochemical corrosion and softening of cast iron in watery solutions of sodium and potassium sulfates and chlorides was investigated. It was found that (1) Corrosion speed is constant (2) Perlitic and ferritic cast iron corrode in water or dissociating electrolytic solutions (3) The pH value of the corroding medium determines the corrosion speed (4) A high oxygen content of the corroding medium increases the deposition of corrosion products (5) Corrosion starts with the graphite components of cast iron (6) A high carbon content in cast iron increases the speed of graphitization (7) The forming of a porous surface corrosion layer slows corrosion attack somewhat. Experiments proved that a slightly graphitized, moist cast iron surface, that had been exposed to air for a few hours, formed a potent corrosion curbing surface layer. Transl. by G G

**N65-31078# General Motors Corp., Bristol, Conn. New Departure Div.**

**INVESTIGATION OF HIGH TEMPERATURE BEARING ELEMENTS Progress Report, 1 Jul.-30 Sep. 1964**

C. J. Zupkus, H. R. Ludwig, and A. R. Leveille [1964] 59 p refs (Contract AF 33(615)-1208) (PR-3; AD-613676)

The Phase I, Part A requirement of screening eight materials has been completed. Test results have been analyzed for both the rolling and sliding specimen configurations and for the oxidation testing. This screening has reduced the number of test materials to three in the Phase I, Part B testing. The testing program for Phase II has been established. Author

**N65-31079#** General Motors Corp., Bristol, Conn. New Departure Div.

**INVESTIGATION OF HIGH TEMPERATURE BEARING ELEMENTS Progress Report, 1 Apr.-30 Jun. 1964**

C. J. Zupkus, H. R. Ludwig, and A. R. Leveille 1 Jul. 1964 35 p refs

(Contract AF 33(615)-1208)

(PR-2; AD-613675)

The 2500° F test rig has been assembled and checked out for reliability. A technique of calibration has been established which eliminates the need for individual calibration curves of strain beam reading versus force. Studies have been conducted to determine the basis of interpreting oxidation behavior and rolling friction forces. The design of the sliding friction test specimen has been established. Author

**N65-31417** European Atomic Energy Community, Brussels (Belgium).

**SOME APPLICATIONS OF THE MICROPROBE IN CORROSION STUDIES**

H. W. Schleicher *In its* On Electron Microprobe Analysis—Quant. and Structural Analysis of Nucl. Mater. Jun. 1964 p 197-204 refs (See N65-31404 20-06) Available from Belg. Am. Bank and Trust Co., New York, Account No. 22.186; 250 Belg. Fr.

Possibilities and limitations are briefly described for the efficient application of the X-ray microanalysator to the study of corrosion problems. Examples are given concerning the corrosion of sintered aluminum powder in terphenyls and water, fouling deposits in organic liquids, and the corrosion of uranium carbide in liquid lead. R.N.A.

**N65-31634#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Materials Lab.

**INVESTIGATION OF BASIC FACTORS INVOLVED IN THE FORMULATION AND CHARACTERIZATION OF ALUMINUM COMPLEX IMIDO ACIDS AS HIGH TEMPERATURE GREASE THICKENERS**

Ernest L. Plummer Oct. 1964 28 p refs  
(AFML-TR-64-324; AD-610248)

This report covers recent studies of aluminum salts of substituted benzoic acids for use as high temperature grease thickeners. It has been shown that although aluminum tri-benzoate can be prepared by the reaction of aluminum isopropoxide with benzoic acid, it is hydrolytically unstable and, on exposure to moisture, hydrolyzes to aluminum dibenzoate monohydroxide. A literature survey on aluminum salts is included in addition to infrared and thermal gravimetric analysis data on the aluminum salts which have been prepared. Author

**N65-31637#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**POLYORGANOSILOXANES—LIQUID BASE OF HIGH TEMPERATURE CONSISTENT OILS**

Ye. M. Oparina, G. S. Tubyanskaya, and R. I. Kobzova 30 Jun. 1965 15 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 1, 1964 p 32-38  
(FTD-TT-65-322/1+2+4; AD-617947)

Comparison is made of various polyorganosiloxane liquids for use as bases in high temperature consistent oils. Temperatures at freezing and boiling points, viscosity at various temperatures, and molecular weights are given;

molecular weights having been determined cryoscopically with a specially developed thermistor. Evaporability of the liquids in a 0.1 mm layer at temperatures between 200° and 350° C and the thermo-oxidation stability of the liquids are given. Polymethylsiloxane liquids, intended for operation at 200° C, have better physico-chemical properties, thermo-oxidation stability, and anti-wear properties than the polyethylsiloxane liquids. With regard to viscosity-temperature and anti-wear properties, the polymethylsiloxanes are better than the polymethylphenylsiloxane liquids. For use as liquid bases at temperatures above 200° C, the polymethylphenylsiloxanes and polymethylchlorophenylsiloxanes are recommended. M.W.R.

**N65-31656** Joint Publications Research Service, Washington, D. C.

**THE EFFECT OF FRICTION ON THE DYNAMICS OF SERVO SYSTEMS**

G. S. Chernorutskiy *In its* Izv. VUZov Instr. Building, Vol. VIII, No. 3, 1965 p 51-58 refs (See N65-31650 20-14) CFSTI: \$5.00

This article presents a method of accounting for the effect of friction on the dynamics of servo systems with random selection of the magnitude of the mechanical resistance. It is shown that in this case all the dynamic indices of the system have a random nature. The concept is introduced of the probability of the realization of given dynamic properties of a system which can be treated as the reliability of the dynamic indices. Author

**N65-31718#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**DETERMINING WEAR RESISTANCE OF FRICTION COUPLINGS BY THE METHOD OF CONSUMING WORKING MEDIUM THROUGH THE SLOTS BETWEEN THE FRICTION SURFACES**

F. Ya. Zagavura 18 May 1965 10 p refs Transl. into ENGLISH from Dopovid i Akad. Nauk Ukr. RSR (Kiev), no. 5, 1964 p 603-606

(FTD-TT-65-69/1+2; AD-617322)

A method is presented for the determination of wear resistance of friction couplings by the measurement of the consumption of the working medium through the gaps between the friction surfaces. The working medium can be gas or liquid. The change in mass per unit time or per unit volume of the working medium or the change in working pressure per unit time allows the automatic measurement and recording of data on the wear resistance of the friction couplings during testing. The method has high sensitivity and does not require costly equipment.

E. E. B.

**N65-31797#** General Electric Co., San Jose, Calif. Vallecitos Atomic Lab.

**GENERAL CORROSION OF MATERIALS FOR NUCLEAR SUPERHEAT APPLICATIONS**

W. L. Pearl, E. G. Brush, G. G. Gaul, and G. P. Wozadilo Washington, AEC, Mar. 1965 129 p refs  
(Contract AT(04-3)-189)

(GEAP-4760) CFSTI: \$4.00

The general corrosion properties of several commercially available materials have been investigated for application as fuel cladding in superheat reactor systems. Each datum point obtained under heat-transfer conditions represented an integrated corrosion response over a temperature gradient along the length of the electrically heated test specimen. An analytical model is developed by which these data may be treated to yield corrosion behavior at a given, specific temperature. Results are reported for a 10000-hour study of several nickel and stainless steel alloys that were exposed isothermally to 1050° and 1150° F

superheated steam Hastelloy-X, Incoloy-825, Inconel-625, and Incoloy-800 had low initial and long-time linear corrosion rates and formed good protective and tenacious oxides up to 1150° F. Type-406 stainless steel had a high initial but low long-time linear corrosion rate and formed a protective and tenacious oxide up to 1150° F. Inconel-600 had adequate corrosion resistance to 1050° F but formed a nonprotective oxide film with a significant portion lost to the system at 1150° F. Type-304 stainless steel had a significant corrosion rate at 1050° and 1150° F but formed a relatively tenacious oxide at both temperatures that eventually reached a limiting thickness with subsequent spalling.

Author

**N65-31865#** Battelle Memorial Inst., Columbus, Ohio.  
**STRUCTURAL CHANGES IN HIGH-STRENGTH STEEL ASSOCIATED WITH STRESS CORROSION AND ITS RELATIONSHIP TO DELAYED FAILURE** Summary Report, 29 Jun. 1964-29 Jun. 1965

D. I. Phalen, D. A. Vaughan, A. B. Tripler, Jr., W. K. Boyd, and C. M. Schwartz 21 Jul. 1965 21 p refs  
 (Contract N0w-64-0267-c)  
 (AD-468171)

Studies of the structural changes associated with stress corrosion and delayed failure in AISI 4340 steel have shown that significant changes take place in both the internal structure and the fracture-surface morphology as a result of specific treatments, particularly the cathodic portion of the corrosion reaction. The incipient stage of stress cracking may be the result of stress corrosion, hydrogen embrittlement, or both, inasmuch as either corrosion or cathodic charging regenerates visible stacking faults in martensite. The regeneration of these stacking faults is believed to be the cause of transgranular fracture in the initial stages of stress-corrosion cracking. Examination of the fracture-surface morphology of stress-corrosion cracked and hydrogen-cracked alloys indicates that, after the initial reaction, hydrogen diffuses to and along prior-austenite grain boundaries and causes intergranular failure. The most likely mechanism for intergranular failure appears to be reduction of prior-austenite grain boundary energy as a result of adsorbed hydrogen. The analysis of fracture morphology of stress-corrosion failures is compared with that of a hydrogen-cracked fracture surface modified by a subsequent anodic treatment in the corrosion medium. Author

**N65-31877#** Battelle-Northwest, Richland, Wash.  
**CORROSION IN SIMULATED PRTR FUEL ELEMENT SURFACE CREVICES**

W. K. Winegardner Jul. 1965 26 p refs  
 (Contract AT(45-1)-1830)  
 (BNWL-83) Available from AEC, Oak Ridge, Tenn.: \$2.00

Two out-of-reactor tests were conducted to study corrosion of Zircaloy-2 in crevices with geometries similar to those existing on heat transfer surfaces of Plutonium Recycle Test Reactor fuel elements. The tests were conducted in high temperature (293° C), lithiated water at a pH of about 10 and used electrically heated, Zircaloy-2 clad test assemblies. Heat flux associated with heated crevices was about 1100 W/in<sup>2</sup>. Examination after 70 days of loop exposure revealed test assembly cladding penetration, up to 0.007 in., in heated crevices. It is felt that the accelerated attack was the result of the concentration of lithium hydroxide by local boiling.

Author

**N65-31884#** Franklin Inst., Philadelphia, Pa. Franklin Inst. Research Labs.

**PRELIMINARY STUDY OF THE ELASTIC ORIFICE AS A FLOW CONTROL DEVICE IN GAS-LUBRICATED BEARINGS** Interim Report

P. Koch Jun. 1965 18 p  
 (Contract Nonr-2342(00))  
 (NASA-CR-64587; I-A2049-23; AD-618210)

The feasibility of using elastic orifices as flow control devices in externally pressurized, gas-lubricated bearings was studied. The configuration used in the study is shown. The configuration was chosen because it showed promise of fulfilling the main criterion for the success of the control device, substantial increase in throat area as the load pressure increased from zero load to a value approaching full bearing load. No attempt was made to design an orifice—only to determine whether it was possible to find values of the parameters such that the criterion was fulfilled for reasonable values of the supply pressure. The major effort was in the solution of the equations for the elastic deformation of the orifice. This was done through the development of a computer program based on a finite difference approximation to the equations of linear elasticity. It was concluded that it is possible to find values of the parameters such that the throat area of the nozzle changes substantially with the load on the bearing.

E. E. B.

**N65-32146#** Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).

**DESCRIPTION OF A LOOP FOR DYNAMIC CORROSION TESTS IN WATER OF HIGH TEMPERATURE [DESCRIPTION D'UNE BOUCLE POUR ESSAIS DYNAMIQUES DE CORROSION DANS L'EAU A HAUTE TEMPERATURE]**

W. Vanmol, R. Hennaut, J. Waty, and W. R. Ruston EU ,TOM, 1965 26 p In FRENCH; ENGLISH summary  
 (Contract EURATOM-089-62-7 RDB)

(EUR-1744.f; EURAEC-1061) Available from Belg. Am. Bank and Trust Co., New York, Account No. 22.186: 40 Belg. Fr.

The loop is specially designed for dynamic corrosion tests at high temperature in high-purity water or water containing additives. The maximum values for the test parameters are 335° C for the temperature, 170 kg/cm<sup>2</sup> for the total pressure, 25 m<sup>3</sup>/h for the flow-rate and 10 m/sec for the water circulation rate on the samples in the present geometry of the test sections. The principle on which operation of the rig is based is described in detail. The material and equipment used in the main and secondary circuits are all of stainless steel. This equipment and that of the auxiliary circuits are described, as well as the extent to which they are interdependent. The account of the characteristics of the unit is completed by a description of the electric control equipment and the automatic alarm and safety devices. Operation of the loop is illustrated by a description of a brief running procedure.

Author

**N65-32254\*#** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

**STRESS CORROSION STUDIES OF AM-355 STAINLESS STEEL**

J. G. Williamson 9 Aug. 1965 22 p  
 (NASA-TM-X-53317) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

The stress corrosion cracking susceptibility of AM-355 stainless steel alloy was studied. This alloy is used extensively for sleeves in flared tube fittings in the S-I and S-IC stages of the Saturn I and Saturn V vehicles, respectively. Various heat treated conditions were investigated and relative stress corrosion cracking susceptibility determined. Of the generally used heat treatments, the fully hardened SCT 1000 treatment was found to be superior in stress corrosion resistance.

Author

**N65-32319#** Brussels Univ. (Belgium)

**A STUDY OF SOME METAL OXIDATION PROBLEMS AND APPLICATION OF IMPEDANCE MEASUREMENT METHODS TO THE STUDY OF RESISTANCE TO CORROSION IN AN AQUEOUS MEDIUM** Final Report No. 1, Part 2

[1964] 21 p refs Transl. into ENGLISH from FRENCH  
 (Contract EURATOM-081-62-5 RDB)  
 (EURAEC-1129, Pt. 2)

For platinum as for gold, the anodal process was found to be accompanied by an immediate and important growth of the electrode capacitance followed by a slow increase with time. This behavior is just the opposite of that shown by metals such as aluminum and zirconium for which the thickening of the oxide diminishes the value of the dynamic capacity. In the case of gold it appears that the increase of capacitance with time can be explained only by the formation of a surface compound endowed with good electronic conductivity and offering a porous structure. In the case of platinum it is difficult to provide positive proof of an oxide film. The fact that the capacity grows has led some authors to reject the theory of the formation of oxide in favor of the concept of chemisorbed oxygen. However, the data presented appears to favor the formation of oxide. Coulometric measurements confirm that the variation of the differential capacitance observed during the anodal oxidation of the gold is accompanied by a growth of the quantity of oxygen formed

E.E.B.

**N65-32322#** Virginia Polytechnic Inst., Blacksburg. Dept. of Metallurgical Engineering.

**THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION** Quarterly Report No. 1, 1 Jun.-30 Sep. 1964

Brownell N. Ferry 30 Sep. 1964 12 p refs Co-Sponsored by EURATOM /ts Rept.-438-1 (Contract AT(40-1)-3208) (EURAEC-1216)

Progress is reported on an investigation to determine the mechanism by which nitrogen affects the susceptibility of austenitic stainless steels to stress corrosion. Emphasis was placed on the following: (1) design and construction of a new nitriding facility; (2) design and construction of chromium and nickel plating apparatus; (3) formulation of procedures for plating nickel and chromium on iron wires; and (4) refinement of the torsional pendulum to facilitate operation

E.E.B.

**N65-32351#** Battelle Memorial Inst., Columbus, Ohio.  
**STRUCTURAL CHANGES IN HIGH-STRENGTH STEEL ASSOCIATED WITH STRESS CORROSION AND ITS RELATIONSHIP TO DELAYED FAILURE** Quarterly Progress Report, Jun. 29-Sep. 28, 1964

D. A. Vaughan, D. I. Phalen, A. B. Tripler, and C. M. Schwartz 23 Oct. 1964 9 p (Contract N0w-64-0267-c) (QPR-1; AD-617785)

The investigation of structural characteristics of AISI 4340 steel, quenched and tempered to produce three strength levels, has been initiated as a basis for the planned studies of these materials under conditions of stress-corrosion attack. Due to problems in contract negotiation, this program was delayed in starting. However, the experimental work, plus a literature study, has been initiated. Preliminary electron metallographic studies of the steel have been carried out in the process of developing techniques. Electron diffraction and X-ray diffraction results are being correlated with the microstructure.

Author

**N65-32693#** Army Biological Labs., Fort Detrick, Md.  
**GRAPHITIZATION OF CAST IRON AS AN ELECTRO-BIO-CHEMICAL PROCESS IN ANAEROBIC SOILS**

C. A. H. von Wolzogen Kühr and L. S. van der Vlugt 3 Mar. 1964 50 p refs Transl. into ENGLISH from Water (The Hague), v. 18, no. 16, 3 Aug. 1934 p 147-165 /ts Transl. No. 1021 (FD3-3957(T-166); AD-617552)

Corrosion of cast iron in the ground was classified as to rust formation or graphitization; iron oxide being the corrosion product of the rust and iron sulfide of graphitization. The fact that extensive corrosion of iron has been observed in

soils with only weak sulfate reduction, even though cast iron pipes in such soils may have a high layer of high iron sulfide content, leads to the conclusion that graphitization is not a purely chemical sulfur corrosion. Sulfate reduction in the ground was considered as a natural accumulation process, and it was concluded that this reduction serves as a depolarizer in the corrosion cell and the iron goes into the solution anodically. This anaerobic corrosion of iron was, therefore, regarded as an electro-biochemical process. Iron pipes are considered unsuitable for soils which are considered to possess chemical sulfate aggressiveness.

M.W.R.

**N65-32849#** Union Carbide Nuclear Co., Paducah, Ky. Paducah Gaseous Diffusion Plant.

**A CHROMATOGRAPH FOR THE ANALYSIS OF HIGHLY REACTIVE AND CORROSIVE COMPOUNDS**

E. L. Williamson, C. M. Johnson, T. J. Mayo, and W. R. Rossmassler 8 Jul. 1965 23 p refs (Contract W-7405-ENG-26) (KY-485) CFSTI: \$1.00

A chromatograph for the analysis of corrosive gases was designed, built, and tested. The instrument features a unique sample valve and a bleed to the carrier system to improve the analysis for hydrofluoric acid. Data on several individual and mixed gases are tabulated.

Author

**N65-32852#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ON CERTAIN CHARACTERISTICS OF IRRADIATING LUBRICANTS WHEN STUDYING THEIR RADIATION RESISTANCE**

Yu. S. Zaslavskiy, A. D. Stukin, and G. I. Shor 6 Jul. 1965 14 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 10, 1964 p 44-48 (FTD-TT-65-325/1+2+4; AD-618011)

The radiation resistance of lubricants, which depends on their chemical make-up and the intensity and type of ionizing radiation to which they are subjected, is discussed. Both reactors and gamma sources are used to irradiate samples of various lubricants, and the use of a dosimeter which measures absorbed dosages in a homogeneous field of radiation is proposed. This dosimeter, using constant specific heat and the linear increase of the rate of sample heating, is dependent on the absorbed radiation dose measured directly in radians. A sample container dosimeter made of aluminum, a polyethylene sensing element, and thermocouples is described.

W.M.R.

**N65-32968\*#** National Aeronautics and Space Administration, Washington, D. C.

**ON THE DISSOLUTION OF ZINC IN ALKALIS [O RASTVORENII TSINKA V SHCHELOCHAKH]**

V. I. Rodionova Sep. 1965 13 p refs Transl. into ENGLISH from Uch. Zap. Mosk. Gos. Ped. Inst. (Moscow), v. 99, 1957 p 221-226

(NASA-TT-F-252) CFSTI: HC \$1.00/MF \$0.50 CSCL 07D

The relationship between the dissolution of zinc and the nature of the alkalis and the concentration of their solutions was investigated. The corrosion rate of zinc depends on the nature of the alkali cation. In all the alkalis investigated, the dependence of the corrosion rate of zinc on the alkali concentration is almost identical. In dilute solutions of alkalis, the corrosion rate of zinc increases with increasing concentration of the aggressive medium, reaching a maximum in one normal solution of potassium hydroxide and lithium hydroxide and in a 3N solution of sodium hydroxide. In medium concentrations of alkalis, the corrosion rate of zinc remains constant and does not depend on the ion concentration of the aggressive medium. In concentrated solutions of most alkalis, the corrosion rate decreases somewhat. The described dependence of the corrosion rate of zinc on the alkali concentration is explained by

the character of the surface compounds that arise during the reaction of zinc with alkali, their composition, structure, properties, and ability to persist on the surface of the metal. The coating film passivating action is confirmed by experiments on the mixing of the alkali solutions. R.N.A.

**N65-32983#** Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaire.

**THE COMPATIBILITY OF VARIOUS AUSTENITIC STEELS WITH MOLTEN SODIUM [COMPATIBILITE DE DIVERS ACIERS AUSTENITIQUES AVEC LE SODIUM FONDU]**  
L. Champeix, J. Sannier, R. Darras, W. Graff, and P. Juste  
1963 28 p refs In FRENCH; ENGLISH summary  
(CEA-2371) CFSTI: HC \$2.00/MF \$0.50

Various techniques for studying corrosion by molten sodium have been developed and applied to the case of 18/10 austenitic steels. The results obtained are discussed as a function of various parameters: type of steel, temperature, oxygen content of the sodium, surface treatment, welds, mechanical strain. In general, these steels have an excellent resistance to sodium when the latter's oxygen content is limited by a simple purification system of the "cold trap" type, and when an attempt is made to avoid cavitation phenomena which are particularly dangerous, as is shown by the example given. Author

**N65-33005#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**WEAR RESISTANCE OF POLYFORMALDEHYDE IN SLEEVE BEARINGS**

V. N. Kestel'man, D. I. Fel'dman, and N. Ya. Kestel'man 9 Jul. 1965 10 p refs Transl. into ENGLISH from *Plasticheskiye Massy* (Moscow), no. 7, 1964 p 65-66  
(FTD-TT-65-329/1+2+4; AD-618058)

Described is a new polymerpolyformaldehyde (PFA) possessing a dense crystalline lattice, which defines its high physico-mechanical properties. The indices of its basic properties are shown. Tests found that sleeve bearings made of PFA are 3 to 4 times more wear resistant than caprone bearings, and 1.5 to 2 times more than cerametal bushings and bearings. The PFA bearings retained stability of dimensions and reliable friction under various conditions of load, lubrication, sliding rate, etc., with a magnitude of wear directly proportional to the friction path. G.G.

**N65-33475#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**LUBRICANT FOR PROCESSES OF UPSETTING AND DRAWING OF METALS**

L. L. Baybakova, Z. G. Smolkotina et al 14 Apr. 1965 5 p Transl. into ENGLISH from Russian Patent No. 161856 (Appl. No. 821339/23-4, 23 Feb. 1963) 1 p  
(FTD-TT-64-1197/1; AD-614960)

The use of calcium soaps of synthetic fatty acid fraction C<sub>5</sub>-C<sub>6</sub> as a lubricant for drawing metals is proposed. The lubricant increases the steadiness of the working tool by a factor of three in the drawing of nonferrous metals (brass and the alloy AMT-5). Good results are also obtained in cold upsetting of wood screw blanks made of brass wire. The technology of the preparation of the lubricant is outlined. W.M.R.

**N65-33491#** Rocketdyne, Canoga Park, Calif.

**RESEARCH IN THE FIELD OF LIQUID-METAL-LUBRICATED BEARINGS** Quarterly Progress Report, Period Ending 15 Jun. 1965

25 Jun. 1965 60 p refs  
(Contract AF 33(657)-10553)  
(R-5086-7; AD-465546)

A program designed to investigate potassium lubricated bearings has been continued. Performance tests of special hybrid bearings in the simulated system test rig using water were concluded and data were reduced. Analyses were performed to predict bearing performance. Correlation between analysis and test data is excellent and typical results are presented. Preparations are now under way for potassium lubricated simulated system tests at temperatures up to 1200° F.

Author

**N65-33652#** Joint Publications Research Service, Washington, D. C.

**CORROSION OF URANIUM AND ITS ALLOYS**

V. V. Gerasimov 26 Aug. 1965 53 p refs Transl. into ENGLISH of 2 Chapters from the book, "Korroziya Urana i Yego Splavov" Moscow, Atomic Publishing House, 1965 p 40-95

(JPRS-31728; TT-65-3223) CFSTI: \$3.00

CONTENTS:

1. CORROSION OF URANIUM ALLOYS IN AQUEOUS MEDIA V. V. Gerasimov p 1-24 refs (See N65-33653 22-17)

2. CORROSION OF URANIUM AND ITS ALLOYS IN NON-AQUEOUS MEDIA AND PROTECTIVE COATINGS V. V. Gerasimov p 25-48 refs (See N65-33654 22-17)

**N65-33653** Joint Publications Research Service, Washington, D. C.

**CORROSION OF URANIUM ALLOYS IN AQUEOUS MEDIA**

V. V. Gerasimov *In its Corrosion of Uranium and Its Alloys* 26 Aug. 1965 p 1-24 refs (See N65-33652 22-17) CFSTI: \$3.00

Various methods of increasing the corrosion resistance of uranium in water and steam are discussed, with particular emphasis on alloying and heat treatment. It was pointed out that the highest resistance was exhibited by alloys of uranium with hafnium, nickel, niobium, titanium, zirconium, molybdenum, and silicon. Effects of different combinations of these alloys on the corrosion resistance are described, in relation to heat treatment and exposure to aqueous media. Tabular data on uranium alloys are included for corrosion rates in boiling distilled water; corrosion resistance in water, and in water and steam. Corrosion rates after various heat treatments are also tabulated. M.G.J.

**N65-33654** Joint Publications Research Service, Washington, D. C.

**CORROSION OF URANIUM AND ITS ALLOYS IN NON-AQUEOUS MEDIA AND PROTECTIVE COATINGS**

V. V. Gerasimov *In its Corrosion of Uranium and its Alloys* 26 Aug. 1965 p 25-48 refs (See N65-33652 22-17) CFSTI: \$3.00

Mechanisms of atmospheric corrosion of pure uranium and uranium alloys are described in relation to the effects of temperature and humidity on the corrosion rates. The influence of the electric field on the oxidation rate of metals, and uranium oxidation according to the linear law are also discussed. Various alloy combinations are considered, and data are given for their resistance under different test conditions. Methods of coating uranium are also described, and test results on the corrosion resistance properties of nickel and silver are tabulated according to method of production, media, temperature, and length of test. The effect of temperature on the oxidation rate of uranium in the steam phase, and the conflagration curve of uranium tempered in oxygen from the  $\beta$ -region are plotted. Tables list the corrosion rates of uranium in water steam, in argon, and in saturated steam; and the free energy of formation of uranium compounds. M.G.J.

**N65-33771#** Naval Research Lab., Washington, D. C. Surface Chemistry Branch.

**SURFACE CHEMICAL METHODS OF DISPLACING WATER AND/OR OILS AND SALVAGING FLOODED EQUIPMENT. PART 4: AGGRESSIVE CLEANER FORMULATIONS FOR USE ON CORRODED EQUIPMENT**

H. R. Baker and P. B. Leach 15 Jun. 1965 17 p refs (NRL-6291; AD-618956) CFSTI: \$1.00

The surface chemical techniques previously reported from this Laboratory for the removal of oily contamination, sea water, and fresh water from electronic and electrical equipment after flooding are not designed to remove the corrosion products which often form on some parts of equipment after salt water exposure. Thickened "paint-on" spot-cleaning compositions have been developed for the removal of such corrosion from aluminum, copper, brass, steel, cadmium plate, and zinc plate. The formulations employ solid chemicals to the maximum extent possible, the solids being combined with water or commercially available mineral acids just before use. The use of such aggressive cleaners may advantageously precede the surface chemical treatment described previously.

Author

**N65-33871#** Southern Research Inst., Birmingham, Ala. **EFFECT OF PROTECTIVE COATINGS ON THE STRESS-CORROSION PROPERTIES OF SUPERSONIC-TRANSPORT SKIN MATERIALS** Eleventh Quarterly Status Report, 1 Jun.-31 Aug. 1965

J. O. Honeycutt and A. C. Wilhelm 24 Sep. 1965 34 p refs (Contract NASr-117)

(NASA-CR-67014) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

Investigation of selected coatings to protect metal substrates of supersonic transport skin materials from stress corrosion continued. Results from the 3000 hr exposures to hot salt at 550° F. and humid salt at 95° F showed that the AM 350 SCT stainless steel substrate will require protection from stress corrosion in salt-laden humid environments, and duplex annealed Ti-8Al-1Mo-1V alloy will require protection from stress corrosion when exposed to dry salt at 550° F. Aluminum-modified silicone provides excellent protection for at least 3000 hr in either hot salt environments at 550° F. or in humid salt environments at 95° F. However, catalytically cured silicone provides protection only at 95° F. and quickly shredded from each substrate in the hot salt environment at 550° F. W.M.R.

**N65-33887#** Joint Publications Research Service, Washington, D. C.

**CLAD STAINLESS STEELS**

S. A. Gladyshevskaya, L. V. Meandrov, S. A. Golovanenko, and A. A. Bykov 21 Sep. 1965 69 p refs Transl. into ENGLISH of 3 Chapters from the book, "Dvukhsloynnye Stali v Khimicheskoy Mashinostroyeni." Moscow, "Mashinostroyeniye" Publishing House, 1965 p 81-147

(JPRS-32087; TT-65-32580) CFSTI: \$3.00

A study is presented on corrosion resistance, fatigue strength, and engineering processes in the manufacturing of clad stainless steels. Discussions are included on clad steel passivity, heat treatment effects on clad steel corrosion resistance, intercrystalline corrosion, overall corrosion resistance in different corrosive media, point corrosion, welding behavior in a corrosive medium, corrosion under stress, fatigue strength in the absence and presence of stress concentrators, engineering properties of bimetals when pressure worked, characteristics of billeting and assembly operations involving bimetals, manual arc and automatic welding, and different articles made of clad steel.

R.N.A.

**N65-33907#** Shell Oil Co., Wood River, Ill. Research Lab. **STUDY OF HELICOPTER GEAR LUBRICATION** Quarterly Progress Report, Mar.-May 1965

D. R. Bailey and S. J. Beaubien [1965] 16 p refs (Contract NOW-65-0323-c)

(QPR-1; AD-618522)

The effect of several gear surface precoatings on gear performance, and the gear performance of a typical synthetic, tetraester, five-centistoke base oil are investigated. It was found that precoating gears by heating in atmospheres of air, or a diester base oil, had little effect on the score load of a MIL-L-23699 test oil, while gears treated in a nitrogen atmosphere gave an increase in score load. Fatigue life as measured by the time to pitting failure, on the other hand, was considerably affected by the precoatings, particularly at high speed. In constant load tests at 6400 rpm it was found that the diester oil precoating extended gear life by a factor greater than seven, while the air precoating increased life three times. Under these same conditions the nitrogen treatment had no effect on gear life. While the coating techniques investigated represent only an initial attempt in this field, the improvement in performance is sufficient to warrant further study. From tests with the synthetic base oil, it was found that this oil is rather insensitive to break-in, and that fatigue failures occurred by fatigue-scoring rather than by pitting.

Author

**N65-33966#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM** Quarterly Progress Report No. 1, Quarter Ending Jul. 15, 1965

R. W. Harrison and E. E. Hoffman 21 Jul. 1965 15 p (Contract NAS3-6474)

(NASA-CR-54477) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

During the first quarter of the program, work proceeded on the topics abstracted below: Material vendors have been contacted, and the ordering of loop construction materials can commence promptly upon notification of the alloy selection by the NASA Project Manager. A lithium shipping container has been designed and constructed. High purity lithium will be purchased from Lithium Corporation of America. Mini-Flex Corporation, Lawndale, California, has demonstrated their capability to fabricate refractory alloy bellows, and an order for Cb-1Zr and T-111 bellows has been placed with this firm.

Author

**N65-34121#** Dynamic Science Corp., South Pasadena, Calif. **RHEOLOGY OF SILICONE FLUIDS THICKENED WITH BORON NITRIDE** Quarterly Report No. 6, 15 Dec. 1963-15 Mar. 1964

15 Mar. 1964 24 p

(Contract AF 33(657)-9155)

(P-51a, QR-6; AD-463719)

The rheological properties of a grease thickened by boron nitride can be improved substantially if the thickener is composed of submicron size particles instead of relatively coarse grains characteristic of commercial grade material. The submicron material is being prepared by gas phase reaction of ammonia and boron trichloride under high nitrogen dilution at a temperature of 900° C. Purification is being effected by vacuum sublimation of the by-product ammonium chloride. Two boron nitrides have been used to thicken QF-6-7039 fluid, and measurements of consistency as a function of solid/fluid ratio have been carried out. Two or three additional fluids, including MLO-60-231 6  $\phi$  ether, will also be thickened. Rheological tests will be conducted on all greases at 77° and 600° F. shear rates will range from 2 to 10000 reciprocal seconds.

Author

**N65-34221\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**VAPOR-DEPOSITED THIN GOLD FILMS AS LUBRICANTS IN VACUUM ( $10^{-11}$  mm Hg)**

Talivaldis Spalvins and Donald H. Buckley Washington, NASA, Oct. 1965 15 p refs

(NASA-TN-D-3040) CFSTI: HC \$1.00/MF \$0.50 CSCL 13H

Thin gold films were vapor-deposited on nickel, nickel-chromium, and nickel rhenium surfaces to be used for lubrication purposes. The durability of the film was determined by friction characteristics. Durability and strong bonding (adhesion) between the film and the substrate are essential when thin films are used as lubricants. Two methods of substrate preparation for vapor deposition were investigated: mechanical polishing and electron bombardment. Friction experiments were conducted with a hemispherical niobium rider sliding on the deposited gold film on a rotating disk. Results of this investigation indicated that the film endurance life during friction experiments was increased when the substrate was electron bombarded and thermally etched prior to vapor deposition on the etched surface at an elevated temperature of 800° F. A diffusion-type interface was believed to be formed between the film and the substrate. Author

**N65-34252\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**CORROSION OF REFRACTORY ALLOYS BY REFLUXING POTASSIUM**

C. M. Scheuermann Washington, NASA, 1965 18 p refs Presented at the 4th Symp. on Refractory Metals, Inst. of Metals Div., AIME, French Lick, Ind., 3-5 Oct. 1965

(NASA-TM-X-52136) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

A summary of corrosion capsule studies to test the resistance of niobium- and tantalum-base tubing alloys to refluxing potassium over the temperature range 1800° to 2400° F, and for times up to 4000 hours, is presented. The various capsules, containing about 1 1/4 cc of potassium, were tested in high-vacuum chambers at pressures of  $10^{-7}$  to  $10^{-8}$  torr. Metallographic examinations were made of all specimens. It was observed that most alloys exhibited surface roughening, or etching. Ungettered alloys were more severely attacked and exhibited solution and intergranular penetration. Gettered alloys, with the exception of Cb-12r, showed only relatively slight effects of potassium corrosion. After 2000 hrs at 1800° F, Cb-12r capsule walls exhibited up to 7.0 mils of intergranular attack and grain removal at the liquid-vapor interface. Vacuum fusion analyses for oxygen showed a greater concentration of oxygen in the bottom sections of several capsules than in the top sections. G.G.

**N65-34319\*** Ohio State Univ. Research Foundation, Columbus.

**A STUDY OF THE MECHANISM OF STRESS CORROSION CRACKING IN THE IRON-NICKEL-CHROMIUM ALLOY SYSTEM** Quarterly Report, 17 Dec. 1964-16 Mar. 1965

R. W. Staehle, F. H. Beck, M. G. Fontana, and J. P. Hirth 5 Apr. 1965 18 p

(Contract AT(11-1)-1319)

(COO-1319-24)

A model for cracking is developed from stress corrosion experiments with iron-nickel-chromium alloys, and studies have been made of the tensile properties of the materials used in these experiments. Conditions resulting in specimens subjected to stress are compared to nonstressed conditions for various alloys; and it is found that, except in the case of very low alloy materials, there is very little oxidation, pitting, or other chemical attack in the absence of stress. The presence of stress promotes oxidation, cracking, and pitting, and these attacks vary with the alloy used. Cracking is found to be both intergranular and transgranular. Scoping studies were initiated to determine the effects of water-oxygen-chloride-environment

on the alloys, and it is shown that there is generally very little attack on the stressed specimens in a water environment. Other environments appear to play an important role according to preliminary studies. Tensile stress, yield stress, and percentage elongation are tabulated at room temperature for the various alloys. M.W.R.

**N65-34370\*** Douglas Aircraft Co., Inc., Newport Beach, Calif. Astropower Lab.

**STRESS CORROSION IN MARTENSITIC HIGH STRENGTH STEELS** Quarterly Report, Nov. 1964-Jan. 1965

C. B. Gilpin, S. M. Toy, and N. A. Tiner Feb. 1965 43 p refs

(Contract AF 33(657)-10744)

(Rept.-132-Q7; AD-463766)

Electron microautoradiographic experiments have indicated that cathodically charged hydrogen in the form of tritium segregated to prior austenite grain boundaries in 4340 steel. After aging at room temperature for two weeks, the tritium was no longer segregated at boundaries but was distributed throughout the material. It was not possible to determine if the tritium concentration was decreased or if the tritium was just redistributed. Metallographic studies of cracks indicate that cracks initiate below the surface at inclusion site outcroppings on the surface. The crack front in the intergranular region of propagation appears to be relatively smooth, whereas in the transition portion it is quite jagged. The principal electrochemical processes taking place during the stress corrosion test are attributed to two cathodic reactions, hydrogen reduction and oxygen ion reduction, which cathodically control the anodic iron oxidation reaction. It is based on the analysis of the effect of oxygen content, pH and tempering on the polarization curves determined for marquenched 4340 steel. These results also form the basis for deriving the electrochemical aspects of stress corrosion cracking by coupling the most active redox reactions. A polarization curve on EF 18% nickel maraging steel in oxygenated 3% NaCl pH 1.5 was determined. Author

**N65-35021\*** Battelle-Northwest, Richland, Wash. Metallurgy Research Section.

**HIGH TEMPERATURE CORROSION OF CANDIDATE ATR STRUCTURAL MATERIALS**

L. A. Charlot and R. E. Westerman Sep. 1965 72 p refs

(Contract AT(45-1)-1830)

(BNWL-100)

Research data in support of the Advanced Test Reactor program of compatibility between structural material and gas are presented. The investigations were primarily concerned with the behavior of Hastelloy X-280, a nickel base alloy, and Haynes Alloy 25, a cobalt base alloy, in static atmospheres of oxygen, methane, carbon monoxide, carbon dioxide, nitrogen, flowing helium, and water vapor at temperatures of 2048° and 2192° F. Evaporation rates of the alloys, and corrosion of weldments in contaminated helium were also studied. Kinetic analyses of the gas-metal reactions were based on continuous weight change determinations. Metallography was employed to evaluate the microstructure of the corroded samples. R.N.A.

**N65-35203\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**DEGRADATION OF POLYMERIC COMPOSITIONS IN VACUUM TO  $10^{-9}$  mm Hg IN EVAPORATION AND SLIDING FRICTION EXPERIMENTS**

Donald H. Buckley and Robert L. Johnson [1964] 30 p refs Presented at the 20th Ann. Tech. Conf., Soc. of Plastics Engr., Atlantic City, 28-31 Jan. 1964.

(NASA-TM-X-54549) CFSTI: HC \$2.00/MF \$0.50 CSCL 11I

Solid compositions studied included PTFE, PCFE, polyimides, both filled and unfilled, and fluorocarbon telomers.



Evaporation experiments were conducted at ambient temperatures to 1100°F and pressures to  $10^{-8}$  mm Hg. Various molecular weights of different polymers were examined. Results indicate that evaporation rates in vacuum for polymers vary with molecular weight. Friction and wear experiments were conducted with a 3/16-inch-radius rider hemisphere (usually polymer) sliding on a flat disk (various materials) at speeds to 1480 feet per minute with a 1000-gram load on the rider specimen and at an ambient pressure of  $10^{-9}$  mm Hg. Fillers were found to influence markedly the wear of PTFE and PCFE in vacuum as a result of changes in heat dissipation properties, but they showed little or no influence on friction. Unfilled polyimide was found superior to unfilled PTFE and PCFE in friction, in wear, and in degradation characteristics. With the aid of a mass spectrometer, the decomposition mechanism for various PTFE compositions was observed during sliding. Author

**N65-35287#** Martin Co., Denver, Colo. Aerospace Div.  
**EVALUATION OF THE MECHANISM OF CORROSION IN CAPILLARIES** Final Report

P. J. Pizzolato, B. K. Larkin, and C. C. Fatino 22 Jun. 1964  
 33 p refs

(Contract AF 04(647)-576)

(DSR-S-11077; CR-64-144; ME-627; AD-602782)

Corrosion mechanisms in a capillary of 2014 aluminum were studied. The corrosive media were products of the reaction between water and a fuel mixture of hydrazine and dimethyl hydrazine, and water and the oxidizer nitrogen tetroxide. Two displacement systems were used with these media. In one the capillary was first filled with water and later displaced by propellant, and in the other the capillary was first filled with propellant and later displaced by water. Two capillary configurations were used: a uniform cylindrical hole and a large cavity connected to a propellant tank by a narrow hole. No evidence of corrosion was found in specimens exposed to fuel and water. Of 89 specimens exposed to oxidizer and water, 60 showed no significant corrosion. The oxidizer corrosion process formed localized pits ranging in depth from 0.0004 to 0.012 inches. No intergranular corrosion was found. The oxidizer corrosion was more severe in the large cavity than in the uniform hole. Diffusion theory shows that corrosive media will not remain in capillaries more than two weeks. Experimental verification was obtained by both corrosion data and liquid analysis. R.N.A.

**N65-35437#** Aluminum Co. of America, New Kensington, Pa. ALCOA Research Labs.

**INVESTIGATION OF THE MECHANISM OF STRESS CORROSION OF ALUMINUM ALLOYS** Final Report, 6 Dec. 1963-6 Feb. 1965

G. C. English [1965] 109 p

(Contract N0w-64-0170-c)

(AD-615789)

The cathodic protection of 7075 alloy in a corrosive, acid chloride solution was investigated. Subsize tensile specimens for protection were taken in the short-transverse direction from 2-inch thick plate in two tempers, one susceptible to stress corrosion and one not susceptible to this type of corrosion. Considerable evidence indicates that the potential protection reflected metallurgical structure rather than extraneous conditions such as the alkalinity produced by cathodic reactions. For all specimens, general corrosion decreased as cathodic protection was increased, first rapidly, and then gradually. Pitting on a microscopic scale ceased by the time a potential 0.20 to 0.25 volts negative to the free corrosion potential was reached. The results suggest strain induced depolarization of the anodic reaction. Electron microscopic examination of prepolished surfaces of cathodically protected specimens shows promise for relating the depolarization to microstructural features. R.W.H.

**N65-35473#** Lund Inst. of Tech. (Sweden).

**ON HYDRODYNAMIC LUBRICATION WITH SPECIAL REFERENCE TO SUB-CAVITY PRESSURES AND NUMBER OF STREAMERS IN CAVITATION REGIONS**

Leif Floberg Stockholm, Royal Swed. Acad. of Eng. Sci., 1965  
 37 p refs *Its Acta Polytechnica Scandinavica, Mech. Eng. Ser. No. 19*

(UDC-621.89.032) CFSTI: HC \$2.00/MF \$0.50

Hydrodynamic lubrication of two lightly loaded rotating circular cylinders is studied. Special reference is here given to sub-cavity pressures and number of oil streamers in cavitation regions. It is shown both theoretically and experimentally how the sub-cavity pressure will influence the number of streamers and the other bearing quantities. The agreement between theory and tests is quite satisfactory. It is shown that the influence of the surface tension can be neglected even at extremely light loads. Calculations are made for pressure distributions, load capacities, and oil flows. Tests are carried out for pressure distributions, load capacities and meniscus locations. Photos are taken showing the cavitation boundaries. Author

**N65-35475\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**STUDIES OF LUBRICATING MATERIALS IN VACUUM**

Robert L. Johnson, Donald H. Buckley, and Max A. Swikert [1964] 32 p Presented by the USAF-Southwest Res. Inst. Aerospace Bearing Conf., San Antonio, 25-27 Mar. 1964 (NASA-TM-X-54555) CFSTI: HC \$2.00/MF \$0.50 CSCL 11H

Evaporation rate, friction, and wear investigations were conducted for studying the properties of lubricating materials in vacuum conditions. Evaporation rates for three polytetrafluoroethylene (PTFE) compositions were determined. The materials examined were an extruded PTFE composition and two molded materials. Results indicate that all three components exhibited lower evaporation rates at the higher temperatures than did a commercial PTFE composition. The extruded composition exhibited a higher evaporation rate than the two molded compositions. It is indicated that if minimum evaporation rate is required, the molded compositions may be more desirable. The evaporation rates for two epoxy compositions were also determined. Friction and wear studies in vacuum conditions explored the behavior during sliding contact for a series of polymeric compositions, binary alloys containing soft film-forming phases, complex alloys with film-forming materials, and a burnished MoS<sub>2</sub> film. A burnished MoS<sub>2</sub> film applied to type 440-C stainless steel in argon with a rotating soft wire brush had good endurance properties but somewhat higher friction than commercially available bonded films. L.S.

**N65-35856** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ONE OF THE METHODS OF DETERMINATION OF FRICTION AND THERMAL FLOW IN SELF-SIMULATING PROBLEMS OF BOUNDARY LAYER**

B. I. Reznikov and Yu. N. Smyslov *In its J. of Appl. Mech. and Tech. Phys.*, No. 1, 1964 4 Mar. 1965 p 74-82 refs (See N65-35850 24-23)

A method is expounded for the determination of friction and heat flow which is not related to the numerical integrations carried out for boundary layer equations. Comparisons are made, and show that for complicated systems sufficiently accurate calculations can be made. C.T.C.

**N65-35941#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**POLYORGANOSILOXANES—LIQUID BASE OF HIGH TEMPERATURE CONSISTENT OILS**

Ye. M. Oparina, G. S. Tubyanskaya, and R. I. Kobzova. 30 Jun. 1965. 16 p. refs. Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 1, 1964. p. 32-38 (FTD-TT-65-322/1+2+4; AD-617947)

A comparative characteristic is given of polyorganosiloxane liquids, offering an interest in the role of liquid bases of high temperature consistent lubs. Polymethylsiloxane liquids as components of lubs, intended for operation at a temperature of 200° C. have the advantage in comparison with polyethylsiloxane liquid (physico-chemical properties, thermo-oxidation stability, antiwear properties) and with polymethylphenylsiloxanes (viscosity-temperature and antiwear properties). For silicon lubs intended for operation at a temperature of above 200° C. polymethylphenyl and polymethyl chlorophenylsiloxanes are recommended. Author

**N65-36192#** Southwest Research Inst., San Antonio, Tex. **LOAD-CARRYING CAPACITIES OF GEAR LUBRICANTS OF DIFFERENT CHEMICAL CLASSES BASED ON RESULTS OBTAINED WITH WADD HIGH-TEMPERATURE GEAR MACHINE USED WITH INDUCTION-HEATED TEST GEARS** Technical Report, Mar. 1960-May 1964

G. A. Beane, IV (AF Aero Propulsion Lab.) and C. W. Lawler Wright-Patterson AFB, Ohio, AF Aero Propulsion Lab., Apr. 1965. 44 p. refs. Prepared jointly AF Aero Propulsion Lab. (Contract AF 33(616)-7223, AF 33(657)-9248; AF 33(657)-11028) (AFAPL-TR-65-23; AD-620294)

The WADD High-Temperature Gear Machine and its operation are described briefly. The procedures used with the machine are shown to provide a realistic means of evaluating and screening lubricants for use in aircraft turbine engines operating at elevated gear and lubricant temperatures. A cross section of oils representing different chemical classes of lubricants was used with the WADD High-Temperature Gear Machine in conjunction with induction-heated test gears. The influence of gear material on load-carrying capacity of gears was studied by using two different steel compositions. Also, the effect of gear temperature on load-carrying capacity was investigated at temperatures up to 700° F. The data generated on the WADD High-Temperature Gear Machine, when compared with that generated on the Erdco Ryder Gear Machine, indicated that the rates obtained were comparable. When using Standard Ryder gears (AMS 6260) and gears made of a high-temperature gear material (Nitalloy-N steel), the load-carrying capacity of a lubricant could not be predicted adequately by using as test gears those composed of an alloy that was different from the alloy that would be used for the intended application. All of the lubricants evaluated when Nitalloy-N steel test gears were used demonstrated a decrease in load-carrying capacity with increasing gear temperature up to about 400° F. Author (TAB)

**N65-36228#** Frankford Arsenal, Philadelphia, Pa. Pitman-Dunn Research Labs

**THE STRESS CORROSION AND ELEVATED TEMPERATURE PROPERTIES OF MAGNESIUM-LITHIUM-SILICON ALLOYS**

Anthony Saia and Ralph E. Edelman. Oct. 1964. 15 p. refs. Presented at the 21st Ann. Meeting, Magnesium Assoc., New York, 5-7 Oct. 1964 (FA-A64-31; AD-620329)

Silicon additions improved the stress corrosion resistance of magnesium-lithium alloys in the as-quenched condition. In the stabilized condition, none of the alloys, with or without silicon exhibited any stress corrosion. The silicon-bearing alloys investigated exhibited improved elevated temperature properties over the alloys without silicon. Author

**N65-36246#** Martin Co., Baltimore, Md. Research Inst. for Advanced Studies

**ON THE MECHANISM(S) OF STRESS-CORROSION CRACKING** Technical Report No. 65-7

E. N. Pugh. Aug. 1965. 66 p. refs. Submitted for Publication (Contract DA-31-124-ARO(D)-258) (AROD-5023-1; AD-620513)

A critical review has been made of some of the major theories of stress-corrosion cracking, with particular reference to the long-standing question of whether a single, generalized mechanism exists. It is concluded, largely on the basis of recent studies of  $\alpha$ -brass and of aged aluminum alloys that several different mechanisms are in fact operative in different systems, so that stress-corrosion cracking must be regarded as a generic term. Consideration is given to areas which require further study. Author

**N65-36286#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**METHODS OF TESTING COMPONENTS AND MATERIALS OF MACHINES AND INSTRUMENTS, ISSUE I**

28 Jan. 1965. 35 p. refs. Transl. into ENGLISH of selected articles from the book "Methods of Testing Components and Materials of Machines and Instruments, Issue I" Moscow, Gosatomizdat, 1961. p. 17-46 (FTD-MT-64-247; AD-612763)

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**N65-36288** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**EXPERIMENTAL INVESTIGATION OF ANTIFRICTION PROPERTIES OF CARBON AND GRAPHITE BASE MATERIALS WORKING IN CONDITIONS OF DRY FRICTION**

S. F. Fonarev, A. A. Kul'bakh, and V. A. Dzhanonson. In its Methods of Testing Components and Mater. of Machines and Instr. 28 Jan. 1965. p. 14-20. (See N65-36286 24-15)

Selection of materials for low-speed open gear transmissions operating without lubrication in aggressive media is considered. When comparative tests were made of cylindrical rollers from various stainless steels and a chrome cast iron, the best combination was a steel on steel (designated as Kh 18) with hardness of working surfaces of teeth equal to 55-60. Allowed pressure per unit length of tooth at peripheral wheel velocity  $v \leq 0.3$  m/sec was  $\approx 70$  kg/cm. Other steel combinations are recommended for short periods of service at this velocity, for these, hardnesses of working surfaces of teeth are found to be about 48 and 50 and allowable pressures are 40 kg/cm and 50 kg/cm. Chrome cast iron on steel or on chrome cast iron as well as another combination steel were not recommended for open gear transmissions working without lubricant. M W R

**N65-36289** Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div  
**INVESTIGATION OF ANTIFRICTION PROPERTIES OF MATERIALS BASED ON GRAPHITE OF BRANDS AG1500—, B83 AND AG1500-CU, WORKING IN CONDITIONS OF DRY FRICTION**

S. F. Fonarev, A. A. Kul'bakh, and V. A. Dzhonson *In its Methods of Testing Components and Mater. of Machines and Instr.* 28 Jan 1965 p 21-31 ref (See N65-36286 24-15)

Carbon-graphite materials in the form of semirings were tested at normal and forced operating conditions for resistance to wear, establishment of temperature rates, and determination of coefficient and moment of friction. A graphitized material (designated brand 15E) without lead impregnation was found to be satisfactory in pair with stainless steel at specific pressures up to 20 kg/cm<sup>2</sup>, coefficient of friction did not exceed 0.27 (slip speed  $v = 0.3$  m/sec). Antifriction properties are improved significantly by impregnation with lead, and the wear of inserts does not change and does not exceed 0.66 mg/cm<sup>2</sup>/hr. Preliminary fitting of inserts must be at specific pressures of 15 to 20 kg/cm<sup>2</sup>, but the lead impregnated graphitized material can be used at specific pressures of more than 30 kg/cm<sup>2</sup>. Impregnation of a brand 15D carbon does not materially improve its antifriction properties. During work of a pair with carbon-graphite inserts, wear of steel rollers is minute and has practically no effect on efficiency.

M.W.F.

**N65-36319#** Naval Research Lab., Washington, D. C. Organic and Biological Chemistry Branch  
**STUDIES TO IMPROVE THE WEAR DURABILITY OF POLYTETRAFLUOROETHYLENE (TEFLON) COATINGS ON ELASTOMERIC VULCANIZATES**

A. G. Sands and E. J. Kohn 30 Jul. 1965 20 p refs (NRL-6298; AD-620355) CFSTI: \$1.00

Methods for improving the wear durability of polytetrafluoroethylene (TFE) coatings on vulcanized elastomeric substrates have been investigated. A high-temperature flame-sintering technique has been developed which substantially improves the abrasion resistance of the TFE coatings, even in contact with rough surfaces such as 12-oz duck canvas. The flame-sintered TFE coatings exhibited a high order of durability in contact with smooth steel and anodized aluminum surfaces. Nonanodized aluminum surfaces were severely abraded by the TFE coatings. The flame-sintering treatment did not appreciably degrade the physical properties of most of the elastomers studied, nor did it adversely affect the frictional properties of the TFE coatings. Stabilizers utilized in gum neoprene and acrylonitrile elastomers tended to interfere in the adhesion of the TFE coating, but cleaning the surface of the vulcanizate with an aromatic solvent prior to application of the coating improved the adhesion. The addition of colloidal boehmite alumina to the aqueous TFE dispersion significantly improved the abrasion resistance of sintered TFE coatings on elastomeric vulcanizates. Self-healing of cracks characterizes these coatings, which accounts in part for the improved wear resistance. Where cracks were present in coatings not containing this additive, peeling of the coating from the substrate was initiated at the edges of the cracks by abrasive wear. The TFE and sintered TFE coatings were comparable in frictional properties but greatly superior in abrasion resistance to a proprietary TFE-filled-resin dry lubricant developed especially for application to rubber items.

Author

**N65-36466#** Los Alamos Scientific Lab., N. Mex.  
**ULTRA HIGH TEMPERATURE REACTOR EXPERIMENT (UHTREX) Quarterly Status Report, Period Ending 20 Jun. 1964**

22 Jul. 1964 23 p  
 (Contract W-7405-ENG-36)  
 (LA(MS)-3112) CFSTI: \$0.50

Continued research conducted under the Ultra High Temperature Reactor Experiment (UHTREX) is reported. Presented are data on inherent problems associated with unsatisfactory leakage rates which inhibited completion of the UHTREX facility construction; a computer program used to produce wiring lists for UHTREX circuits; reactor components (design, fabrication, and testing); the helium cooling system; systems analyses; neutronic calculations; and graphite corrosion. S.C.W.

**N65-36540#** General Electric Co., Schenectady, N. Y. Knolls Atomic Power Lab.  
**CORROSION RESISTANCE OF CONSOLIDATED ZIRCALOY-2 POWDER CONTAINING OXYGEN AND NITROGEN**

A. E. Bibb, A. P. Beard, and J. F. Fascia Jun. 1964 13 p refs (Contract W-31-109-ENG-52) (KAPL-3060)

This report covers work on the corrosion characteristics of consolidated Zircaloy-2 powder containing additions of oxygen and nitrogen. Oxygen (>2700 ppm) and nitrogen (>100 ppm) additions reduced the time to transition in 680 F water and had a deleterious effect on both the 680 F water and 750 F steam corrosion resistance of consolidated Zircaloy-2 powder. Linear relationships for hydrogen weight gains were a function of oxygen weight gains irrespective of whether the data were obtained pre- or post-transition. The data suggest that the hydrogen uptake characteristics are an inherent property of the alloy and depend only on the magnitude of corrosion. Nitrogen reduced the tendency for the Zircaloy-2 to pick up the hydrogen generated in the aqueous corrosion reaction.

Author

**N65-36569#** Thompson Ramo Wooldridge, Inc., Cleveland, Ohio. Electromechanical Div.

**SNAP 2 POWER CONVERSION SYSTEM. MERCURY MATERIALS EVALUATION AND SELECTION GFY-1963 Topical Report No. 24**

James F. Nejedlik 30 Mar. 1964 150 p refs Prepared for Atomics Intern.

(Contract AT(11-1)-GEN-8)  
 (TRW-ER-5643; NAA-SR-6316) Available from AEC, Oak Ridge, Tenn.: \$3.45 (Declassified)

SNAP 2 is the designation for a 3 kilowatt nuclear auxiliary power unit to be used in a satellite vehicle. It is a Rankine power system consisting of a reactor heat source, a boiler, a condenser, a mercury turbine, and an alternator. Corrosion of the system by the working fluid, mercury, results in two undesirable effects: (1) wall penetration and (2) mass transport of corrosion products. Judicious choice of materials can only be made with a knowledge of corrosion behavior. Furthermore, to make use of conventional materials of construction corrosion product removal is desirable to reduce fouling tendencies of the power system. Consequently, corrosion, mass transfer, and corrosion product removal were investigated and the results are presented. This report covers the materials investigation for the Fiscal Year 1963.

Author

**N65-36739#** Rock Island Arsenal Lab., Ill. Research and Engineering Div.

**ANODIC PASSIVATION OF STAINLESS STEEL**

Linden H. Wagner May 1965 48 p refs (RIA-65-1190; AD-619152)

Cathodic activation, anodic and immersion passivation treatments on types 310, 321, 410 stainless steel panels, and M1 gas cylinders were investigated in 5% solutions of Na<sub>2</sub>SO<sub>4</sub>, Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>. Passivation in 20% HNO<sub>3</sub> containing 2% Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> was conducted as described in MIL-STD-171A. A Sargent Recorder, Model MR, an automatic self-balancing potentiometer, was used to measure potentials with reference to a normal Calomel-cell and a salt

bridge in contact with a stainless steel panel in an auxiliary vessel containing 0.001N NaCl. Potential vs. time measurements were plotted graphically to show the effects of the treatments on the stainless steels. Passivation treatments increased the positive potential; activation increased the negative potential; half-cell potential measurements showed a decay in panel potential vs. time in air exposure. Passivated panels in salt spray exposure afforded slightly better protection than the control panels. Passivated panels in outdoor exposure showed no appreciable difference between the types of stainless steels in the prevention of corrosion. Author(TAB)

**N65-36775\* #** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**VAPOR DEPOSITED GOLD THIN FILMS AS LUBRICANTS IN VACUUM ( $10^{-11}$  mm Hg)**

T. Spalvins and D. H. Buckley Washington, NASA, 1965 23 p refs Presented at 12th Ann. Vacuum Symp., Am. Vacuum Soc., New York, 29 Sep.-1 Oct. 1965

(NASA-TM-X-52125) CFSTI: HC \$1.00/MF \$0.50 CSCL 13H

Gold thin films of 1800 Å to be used as lubricants were vapor deposited on Ni, Ni-Cr and Ni-Re substrates. Strong bonding (adhesion) and durability between the film and substrate were found to be essential when thin films are used as a lubricant. Factors which were investigated included the selection of the film and substrate material. Strong durability of the thin film is directly related to the type and structure of the interfacial region. Two methods of substrate preparation prior to vapor deposition were investigated: (1) mechanically polished surface and (2) electron bombarded surface. Gold was vapor deposited on the mechanically polished surface at room temperature and on the thermally etched surface at an elevated temperature approximately (800° F). Strength and durability of the films were investigated in sliding friction experiments with a hemispherical niobium rider sliding on the films at a velocity of 5 feet per minute. Results obtained in these friction experiments indicated that the film endurance life was considerably better on the thermally etched surface. This increased film durability with the thermally etched surface is believed to be due to the formation of a diffusion type interface between the film and the substrate. Author

cracking in the media studied. U-bend specimens of vanadium showed evidence of stress corrosion cracking in 6 N hydrochloric and 18 N sulfuric acids; however, tensile stress specimens exposed to these solutions did not exhibit stress cracking. Similar results were obtained when U-bend specimens of molybdenum were immersed in 10 percent formic acid. Titanium-10 percent vanadium alloy was susceptible to stress corrosion cracking in 10-percent (2.85 N) hydrochloric acid solution. Heat treating the alloy greatly reduced its corrosion rate and its susceptibility to stress corrosion cracking in this medium. Author

**N66-10295\*** National Aeronautics and Space Administration, Washington, D. C.

**CORROSION OF TITANIUM ALLOYS OF SERIES VT AND AT IN SOLUTIONS OF SULFURIC ACID CONTAINING NICKEL SULFATE**

S. A. Nikolayeva and V. A. Zinov'yev *In its Phys. Met. of Titanium* Nov. 1965 p 175-180 refs (See N66-10276 01-17) CFSTI: HC \$7.00/MF \$1.75

A study was made to determine the influence of nickel and copper sulfate additions on the corrosion properties of titanium in sulfuric acid. Also investigated was the corrosion behavior of titanium alloys of series VT and AT. The corrosion resistance of sheet, rod, and forged titanium was determined. The obtained corrosion rates for the VT and AT alloys are tabulated, and conclusions are reached from this table. Various curves representing the corrosion rate versus sulfuric acid concentration in the presence and absence of nickel sulfate were examined, and the conclusions are given. A series of experiments devoted to the study of the influence of copper sulfate additions are included. C.T.C.

**N66-10297\*** National Aeronautics and Space Administration, Washington, D. C.

**CHEMICAL STABILITY OF TITANIUM IN HYDROHALIC ACIDS AND HALOGENS**

Kh. L. Tseytlin, L. L. Fayngol'd, and V. A. Strunkin *In its Phys. Met. of Titanium* Nov. 1965 p 188-201 refs (See N66-10276 01-17) CFSTI: HC \$7.00/MF \$1.75

A study was conducted to determine the effect of halogens on the corrosion of titanium by hydrohalic acids; the chemical stability of titanium toward chlorine, bromine, and iodine; and the effect of aromatic nitro compounds on the corrosion of titanium by hydrochloric acid. It was found that free halogens markedly inhibit the corrosion of titanium by hydrochloric, hydrobromic, and hydriodic acid. Also, titanium ignites at room temperature in dry gaseous chlorine (from a cylinder) in 24 hours, in liquid bromine in 10 min, and in dry crystalline iodine at 100° C in 15 min. Water inhibits the reaction of titanium with liquid bromine, but does not exclude a strong localized attack. The use of titanium equipment was found to be inadmissible in cases where the separation of bromine as a separate phase is possible. A tabulation of the effect of aromatic nitro compounds on the rate of titanium corrosion is included. C.T.C.

**N66-10098#** Bureau of Mines, College Park, Md. College Park Metallurgy Research Center.

**STRESS CORROSION CRACKING OF VANADIUM, MOLYBDENUM, AND A TITANIUM-VANADIUM ALLOY**  
J. P. Carter, C. B. Kenahan, and David Schlain 1965 21 p refs (BM-R1-6680)

Vanadium, molybdenum, and a titanium-10 percent vanadium alloy were evaluated for their susceptibility to stress corrosion cracking in a number of corrosive media. Tests were conducted utilizing conventional U-bend techniques with subsequent evaluation in a pneumatic constant-load apparatus. Vanadium and molybdenum were generally resistant to stress corrosion

**N66-10298\*** National Aeronautics and Space Administration, Washington, D. C.

**EFFECT OF SODIUM NITRATE ON THE CORROSION OF TITANIUM BY HYDROCHLORIC AND SULFURIC ACID**

Ya. I. Sorokin and Kh. L. Tseytlin *In its Phys. Met. of Titanium* Nov. 1965 p 202-210 refs (See N66-10276 01-17) CFSTI: HC \$7.00/MF \$1.75

A study was conducted to determine the influence of sodium nitrate on the corrosion of titanium by hydrochloric and sulfuric acid. The experimental methods are given, and graphs showing corrosion rates versus testing times are included.

## 1966 STAR ENTRIES

It was found that titanium VT1-1 displays a satisfactory stability in 20 percent hydrochloric and sulfuric acid at temperatures up to 10° C. and corrodes substantially at temperatures above 20° C. Additions of certain sodium nitrite concentrations to hydrochloric and sulfuric acid impart a positive electrode potential sufficient for chemical passivation to the surface of titanium. Sodium nitrite markedly decreases the corrosion of titanium by acids only under certain testing conditions. In order to provide for a satisfactory stability in 20 percent hydrochloric and sulfuric acid, it is necessary to add 0.01 percent  $\text{NaNO}_2$  at 20° C and 0.1 percent  $\text{NaNO}_2$  at 60° C. C T C.

**N66-10428\*** Thompson Ramo Wooldridge, Inc., Cleveland, Ohio TRW Equipment Labs

**THE CORROSION OF SUPERALLOYS BY LITHIUM FLUORIDE IN A CYCLIC HIGH TEMPERATURE ENVIRONMENT**  
Engineering Report, Jul. 1963-Jul. 1965

R C Schulze 21 Jun 1965 149 p refs

(Contract NAS3-2779)

(NASA-CR-54781 TRW-FR-6561) CFSTI HC \$4.00/MF \$1.00 CSCL 11F

Eleven superalloys were evaluated to determine their resistance to corrosion by lithium fluoride in a cyclic temperature environment. The tests were operated under simulated NASA Brayton Cycle system conditions (maximum lithium fluoride temperature—1850° F, minimum: lithium fluoride temperature—1500° F) to determine the best material for fabrication of the heat receiver. The results of the program indicated Haynes alloy No. 25 to be the best alloy.

Author

**N66-10521\*** Deutsche Versuchsanstalt für Luft- und Raumfahrt, Munich (West Germany). Institut für Flugtrieb und Schmierstoffe

**LUBRICATION AT SPACE CONDITIONS [SCHMIERUNG UNTER WELTRAUMBEDINGUNGEN]**

G. Spengler and F. Wunsch Aug 1965 118 p refs In GERMAN; ENGLISH summary

(DVL-434, DLR-Mitt-65-07) CFSTI: HC \$4.00/MF \$0.75

Operation of equipment in space vehicles has created new requirements on lubricants. The lubricants are subject to additional influences, such as zero gravity, meteorites, various forms of radiation energy, temperature extremes, and ultra-high vacuum. The paper critically reviews the literature on the development and testing of suitable lubricants.

Author

**N66-10669\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

**INVESTIGATION OF THE COEFFICIENT OF FRICTION OF VARIOUS GREASES AND DRY FILM LUBRICANTS AT ULTRA HIGH LOADS FOR THE SATURN HOLD DOWN ARMS**

K. E. Demorest and A. F. Whitaker 14 Sep. 1965 34 p refs (NASA-TM-X-53331) CFSTI: HC \$2.00/MF \$0.50 CSCL 11H

A series of high load, low speed sliding friction tests was made on 8 fluid lubricants and 18 dry lubricants at normal unit loads from 10,000 psi to 150,000 psi. Four different substrate materials having a range of hardnesses from Rockwell C 18 to Rockwell C 55 were used. The ultimate load capability of both fluids and dry films is a function of substrate hardness with the best ultimate load capability being provided by inorganically bonded molybdenum disulfide films with small amounts of graphite added. The coefficient of friction of the

fluid lubricants appears to be an inverse function of substrate hardness and a direct function of the normal load. The coefficient of friction of the dry lubricants is an inverse function of the normal load, but it does not appear to be related to the substrate hardness.

Author

**N66-10698#** Oak Ridge National Lab., Tenn.

**LABORATORY CORROSION STUDIES FOR THE HIGH FLUX ISOTOPE REACTOR**

J. L. English and J. C. Griess Jun. 1965 23 p refs

(Contract W-7405-ENG-26)

(ORNL-TM-1029)

Studies conducted under a corrosion test program designed to examine the behavior of several materials considered for permanent or semipermanent installation in the High Flux Isotope Reactor (HFIR) system, are reported. Both static tests and dynamic tests were performed. Presented are results obtained in the static tests. Major emphasis was placed on the procurement of long term data, however, short term data were also obtained. Reported are experimental data on the following materials: aluminum in contact with metallic materials, aluminum in contact with nonmetallic materials, stainless steels and related materials, plastics, and miscellaneous materials.

S.C.W.

**N66-10777#** Oklahoma State Univ., Stillwater.

**FRICTION REDUCTION EFFECTS ON TURBULENT FLOWS OF WATER IN ROUGH PIPES BY DILUTE ADDITIVE OF HIGH MOLECULAR WEIGHT POLYMER**

E. Rune Lindgren Jun. 1965 26 p refs

(Contract Nonr-2595(05))

(TR-1:AD-621070)

An experimental investigation was made of the reduction of frictional losses in turbulent flows of distilled water through rough tubes by dilute additives of polyethylenoxide of molecular weight 4,000,000. Remarkable reduction of the turbulent energy losses were obtained for 0.002–0.006% concentration of additive in the flow, even to values lower than for smooth turbulent flows.

Author (TAB)

**N66-10787#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**METHOD OF CORROSION RETARDATION FOR STEEL AND IRON IN ACIDS AT HIGH TEMPERATURES**

R. N. Volkov, A. Ya. Shatalov, and S. A. Kononovich 26 Aug. 1965 5 p Transl. into ENGLISH from Soviet Patent No. 162739 (Appl. No. 847640/22-2, 16 Jul. 1963) 1 p

(FTD-TT-65-770/1+4; AD-621040)

The object of the invention is a method of corrosion retardation for steel and iron in acids, at high temperatures. Chloride benzyl quinoline is added as an acid inhibitor.

Author (TAB)

**N66-10873#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**FRICTION BEARING**

Yu. A. Sokolov 23 Jul. 1965 3 p Transl. into ENGLISH from Soviet Patent no. 165042 (Appl. no. 850089 24-6, 27 Jul. 1963) 2 p

(FTD-TT-65-517/1+2+4; AD-619468)

A friction (sliding) bearing for rapid-action machines, such as, a turbo compressor is described. The bearings contain a floating bushing with two surfaces of friction. The distinguishing feature for improving the antifriction qualities with great speeds of friction the inner surfaces of the sleeve and seat of the support are designed with V-shaped oil pockets.

Author (TAB)

**N66-10876\*** Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.

**STRESS CORROSION CRACKING OF TITANIUM ALLOYS**  
Fourth Quarterly Progress Report, 1 Jan-31 Mar. 1965

Sheldon P. Rideout, McIntyre R. Louthan, Jr., and Clifford L. Selby Sep. 1965 24 p refs  
(NASA Order R-124; Contract AT(07-2)-1)  
(NASA-CR-67710; DP(NASA)-1005) CFSTI: HC \$1.00/  
MF \$0.50 CSCL 11F

Research was directed toward determination of the mechanism of hot-salt cracking of Ti-8Al-1Mo-1V. Radiographic evidence showed that  $^3\text{H}$  and  $^{36}\text{Cl}$  are retained on sample surfaces, probably as HCl, after exposure to aqueous salt solutions. Adsorption of HCl appears to be a key factor in causing susceptibility to hot-salt cracking. Exposure to anhydrous HCl gas at 650° F caused abrupt mechanical rupture in stressed samples. Exposure of liquid NaOH at 650° F caused corrosion and preferential attack of aluminum, but no cracking. Aluminum is also preferentially attacked by NaCl during hot-salt cracking. Prior treatments with NaOH, which preferentially remove the aluminum from the sample surfaces, delayed the inception of stress cracking during subsequent exposures to solid NaCl or HCl gas. Results are interpreted to show that hot-salt cracking and HCl-gas cracking are similar and occur by either hydrogen embrittlement or by localized, stress-accelerated corrosion. Author

**N66-11076#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ADDITIVES TO OILS AND FUELS** Collection of Articles  
S. E. Kreyna, P. I. Sanina, V. N. Monastyrskogo, and Ye. A. Eminova, ed. 6 Apr. 1965 669 p refs Transl. into ENGLISH of the book "Prisadki k Maslam i Toplivam" Moscow, Gos. Nauchno-Tekhn. Izd. Neft. i Gorno-Toplivnoy Lit., 1961 p 1-395  
(FTD-MT-64-213; AD-619383)

A collection of articles on the synthesis of detergent, antioxidant, anticorrosion, antiwear, and other additives to petroleum products is presented. For individual titles see N66-11077-N66-11133.

**N66-11077** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**CONTEMPORARY REQUIREMENTS FOR QUALITY OF MOTOR OILS**

Ye. N. Firsanova *In its* Additives to Oils and Fuels 6 Apr. 1965 p 4-15 refs (See N66-11076 02-15)

Tests were conducted to determine characteristics of various Soviet and other lubricating oils when used in winter weather to start and maintain internal combustion machines. Good properties were found for SAE-10, SAE-10W/30, SAE-10W/20 and other oils when prepared with thickening additives of polymethacrylates and polyisobutylenes. It is shown that oils with a high index of viscosity give better starting capabilities under the same temperature conditions. During operation of tractor diesel engines under winter and nominal load conditions, least wear resulted with an oil of 7 to 8 cs and a viscosity index near 100. Experiments with sulfur-bearing oils are reported; Soviet samples with 1% sulfur content are found to possess unsatisfactory alkalinity as compared to "foreign" samples. Use of various grades of oil is discussed, and it is pointed out that lack of standardized rating methods for oils makes it difficult to present reliable quality and usage classifications. M.W.R.

**N66-11078** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**TECHNICAL REQUIREMENTS FOR QUALITY OF DIESEL FUELS AND OILS AND RESULTS OF TESTS OF SOME ADDITIVES**

G. A. Morozov *In its* Additives to Oils and Fuels 6 Apr. 1965 p 16-28 refs (See N66-11076 02-15)

Use of various sulfur-bearing lubricating oils is considered for different groups of diesel engines. A classification is made according to sulfur-content of the oils and various experimental and industrial additives used. Results are reported for the influences of additives on varnish formation and corrosion capacity of an oil designated DS-11. One additive which is shown to significantly lower engine wear does not have sufficient detergent capability. Another table lists general and piston wear, stuck rings, ash content, and acid number of the various additives to the DS-11, which has 0.8% sulfur content. A listing of oils for use with three types of diesel engines is included; and these groups of engines are classified according to degree of forcing. M.W.R.

**N66-11079** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ALKYLPHENOL ADDITIVES OF FORMALDEHYDE CONDENSATION**

A. V. Druzhinia, G. S. Tarmanyan, M. S. Myachina, and I. V. Morozova *In its* Additives to Oils and Fuels 6 Apr. 1965 p 30-39 refs (See N66-11076 02-15)

Two motor oil additives were prepared in both alkaline and acid media, the latter in the presence of alkylphenol sulfa acid. Additive vnii np-370 contained calcium and vnii np-371 barium; the salts are products of alkylformaldehyde condensation and possess high detergent properties. A ratio of 2:4 moles for formaldehyde and alkylphenol, respectively, gives the best physical-chemical characteristics for the vnii np-370. Decrease in alkylphenol content is found to lower ash content and viscosity of this additive, but good solubility in the motor oil is maintained. Studies made of increased ash content in vnii np-371 indicate that an 18 or 25% barium oxide addition produces sufficient capabilities. The barium additive of alkylphenol condensation possesses effective anticorrosive properties and has good color. Both additives passed bench tests on different motors during 100-hour tests with a sulfur-bearing automobile oil and a diesel oil. M.W.R.

**N66-11081** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SYNTHESIS OF DIESTERDITHIOPHOSPHOROUS ACIDS AND OF THEIR DERIVATIVES ON THE BASIS OF SUBSTITUTED PHENOLS AND APPLICATION OF THEM AS ADDITIVES TO OIL PRODUCTS**

V. N. Tishkov, V. I. Isagulyants, Hsiu-Cheng Chang, and N. M. Utsmiyeva *In its* Additives to Oils and Fuels 6 Apr. 1965 p 51-72 refs (See N66-11076 02-15)

Thirty-five multifunctional and antioxidant additives were synthesized in almost pure form from diesterdithiophosphoric (DTP) acid; and a calcium salt designated IP-22k was adopted for industrial usage on the basis of performance tests conducted in the laboratory. A tabulation is made of the characteristics of alkylphenols and their disulfides obtained as initial and intermediate products during the syntheses as well as the various barium, calcium, and zinc salts of DTP acid. Properties of resultant binary compounds of the DTP acid with aliphatic amines and amides, and ash-free additives of triesters of dithiophosphoric acid, esters of diamisothiophosphoric acid, and phenolate-type compounds are also considered. M.W.R.

**N66-11082** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SYNTHESIS, RESEARCH, AND APPLICATION OF SULFONATE ADDITIVES TO LUBRICATING OILS**

A. M. Kuliyev, K. I. Sadykhov, and M. A. Mamedov *In its* Additives to Oils and Fuels 6 Apr. 1965 p 73-87 refs (See N66-11076 02-15)

Several salts of sulfonic acids of alkyl aromatic hydrocarbons were synthesized; and effectiveness of the resultant compounds on motor and diesel oils was studied in relation to molecular weight, structure, and other characteristics of the metal entering the compound. Results with SB-3 additive indicate improvement in initial detergent and anticorrosive properties of various lubricating oils, but that it is necessary to add antioxidants to this additive when sulfurous fuels are used.

M.W.R.

**N66-11083** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **SYNTHESIS OF ANTIWEAR ADDITIVES TO OILS**

I. D. Afanas'yev *In its* Additives to Oils and Fuels 6 Apr. 1965 p 88-101 (See N66-11076 02-15)

Sulfurous antiwear additives have been synthesized on ethylene sulfide and fatty acid bases, and properties of sulfide and disulfide additives are tabulated. Results are given for tests of antiwear properties and thermochemical stability of these additives as well as those of oil additives on a base of xanthogenates of alcohols and of dichloroethane. All of the products synthesized are good inhibitors and have good antiwear properties to both synthetic and petroleum oils. Other type additives considered are crystal xanthogenate, xanthol, and sulfur- and phosphorus-containing. Very effective antiscoring properties are found for xanthogenate-type additives of low-molecular monatomic alcohols and dichloroethane; and both liquid and crystal products can be obtained. Activity of antiwear additives tested on a four-ball machine is shown to increase with decrease in length of hydrocarbon radicals taken for a synthesis of alcohols.

M.W.R.

**N66-11084** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **ORGANO-PHOSPHOROUS AND ORGANO-CHLORINE COMPOUNDS AS ADDITIVES, REDUCING WEAR IN CONDITIONS OF THRESHOLD FRICTION**

Ye. S. Shepeleva and P. I. Sanin *In its* Additives to Oils and Fuels 6 Apr. 1965 p 102-107 refs (See N66-11076 02-15)

Laboratory procedures are given for obtaining tributylphosphite and Cloreth-40 (dibutyl ester of trichloromethylphosphine acid), additives for use in reducing wear resulting from friction. Initial tests using Cloreth-40 as an additive to transmission oil gave encouraging results, so production of experimental lots of the additive were made by a distillation process which reduced content of acid chloride and acid ester impurities.

M.W.R.

**N66-11085** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **EFFECTIVENESS OF CERTAIN ORGANO-MOLYBDENUM AND ORGANO-SULFUR COMPOUNDS AS ANTIWEAR ADDITIVES TO LUBRICATING MATERIALS**

A. A. Fal'kovskaya, A. Ya. Vavul, Ye. M. Kheyfets, I. B. Rapoport, V. A. Listov et al *In its* Additives to Oils and Fuels 6 Apr. 1965 p 108-121 refs (See N66-11076 02-15)

A molybdenum-base additive (V-15/30) is found to sharply increase antiwear properties of mineral and synthetic lubricating materials, particularly during joint application with compounds containing sulfur of chlorine. Thermo-oxidizing stability of this additive is, however, unsatisfactory. An organo-molybdenum additive (V-15/1) may be used successfully for preliminary application of noncorroding films on friction surface for high temperature lubrication; there is reduction of wear on metal and no fusing of metallic surfaces under large loads. Organo-sulfur additive (V-15/2A) is found to be a very effective antiscoring additive to high temperature lubricating materials. A copolymer with 1.5% additive V-15/2A insures proper working of roller bearings at a temperature of 350°C.

M.W.R.

**N66-11086** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **ANTIOXIDANT ADDITIVES TO LUBRICATING OILS ON A BASE OF PRODUCTS OF REACTION OF PHOSPHORUS PENTASULFIDE AND TERPENES**

A. M. Ravikovich and I. V. Ladyzhenskaya *In its* Additives to Oils and Fuels 6 Apr. 1965 p 122-132 refs (See N66-11076 02-15)

Organo-phosphorus antioxidant additives are obtained by a reaction of phosphorus pentasulfide with terpenes in the presence of sulfuric acid. The obtained additives have a high phosphorus content and are stable during storage. Reaction of  $P_2S_5$  with terpenes in the presence of  $AlCl_3$  produced less high-polymer insoluble substances than is obtained by the usual method without the  $AlCl_3$ . The presence of  $AlCl_3$  produced additives with higher phosphorus and sulfur content, greater stability, and better solubility in lubricating oils. These additives give a higher thermo-oxidizing stability to mineral oils in thin films.

M.W.R.

**N66-11087** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **METAL DIALKYL DITHIOPHOSPHATES AS ANTIOXIDANTS OF LUBRICATING OILS**

P. I. Sanin, V. V. Sher, L. F. Chernyavskaya, N. V. Melent'eva, and I. S. Glukhoded *In its* Additives to Oils and Fuels 6 Apr. 1965 p 133-147 refs (See N66-11076 02-15)

Dialkyl dithiophosphates containing secondary hydrocarbon radicals are found to be more active antioxidants than those with primary hydrocarbon radicals. Greatest activity is at temperatures below 150°C. Substantial increase in temperature weakens the antioxidant action, apparently because of thermal decomposition of the additive. Oxidation of oils is hindered only slightly by sulfonate-type additives and alkylphenolates. Antioxidant activity increases significantly with the addition of sulfide or dithiophosphate to the alkylphenolates. Ionol and DF-1 are found to be the most active antioxidants. It was found, however, that DF-1 does not delay the oxidation of hydrocarbons of a DS-8 oil which contains natural inhibitors, i.e., aromatic hydrocarbons and sulfurous compounds. In the presence of metals the natural inhibitors are so inactive that the oil becomes unstable; metal dialkyl dithiophosphates, such as DF-1, passivate metals and increase stability of the hydrocarbons with respect to oxidation.

M.W.R.

**N66-11088** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **SYNTHESIS OF NEW ANTIOXIDANT ADDITIVES TYPE OF SHIELDED PHENOLS**

Y. I. Isagulyants and N. A. Facorskaya *In its* Additives to Oils and Fuels 6 Apr. 1965 p 148-160 refs (See N66-11076 02-15)

Synthesis is described for 2,2'-methylene-bis (6-tert-butyl-4-methylphenol) on a base of n-cresol. The alkylation reaction is described and the condensation reaction of 2-tert-butyl-4-methylphenol with formaldehyde is detailed. Antioxidant effect on ethyl gasoline exceeds that of the additive Ionol. Synthesis of two other additives is also outlined: (1) 2,2'-methylene-bis (4,6-di-tert-butyl-3-methylphenol) on a base of dicresols containing 60.7% m-cresol and (2) disulfide of bis-phenol-disulfide (4,6-di-tert-butyl-3-methylphenol). Both of these are effective as a 0.005% antioxidant additive to synthol and are equivalent to Ionol. In transformer oil, the effectiveness of the latter is also equivalent to that of Ionol, but the former gives negative results in a 3% concentration. Synthesis of these two additives permits the use of a by-product obtained in the production of Ionol, 4,6-di-tert-butyl-3-methylphenol, which up to this point was an unused waste.

M.W.R.

**N66-11092** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SYNTHESIS AND INVESTIGATION OF ADDITIVES INCREASING LUBRICATING PROPERTIES OF OILS**

A. M. Kuliev and A. A. Atal'yan. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 191-197 (See N66-11076 02-15)

The synthesis of chlorine and sulfur aromatic hydrocarbons was conducted and the properties of these additives for the improvement of lubricants were investigated. The results of tests of oils with and without additives are tabulated. It was found that the wear of gear teeth when operated on an oil with additive was about half that when operated on an oil without additive. With an increase of the additive concentration, antiwear properties of the oils increase and attain a maximum with an addition of 7 to 10% additive. Also, the synthesis of complex esters from naphthenic and stearic acids and ethylene glycol or phenol was investigated. It was found that esters obtained from unchlorinated acids do not increase antiwear properties of oils. E.E.B.

**N66-11093** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ADDITIVES ENSURING UNIFORMITY OF SLOW MOVEMENT OF UNITS OF METAL-CUTTING MACHINES**

R. N. Osher. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 198-202 (See N66-11076 02-15)

Salts of high-molecular fatty acids, stearates and oleostearates of aluminum in concentrations of 1.6% to 2.7%, were found to give optimum results as anti-skip additives to industrial oils. Being easily adsorbed on metallic surfaces, these soaps decrease the influence of surface defects and change the form of the sliding surface. Aluminum stearate also improves the antiwear and anticorrosive properties of oil by the high viscosity promotion of the formation of lubricating layers of sufficient thickness to reduce wear and lowering of the pour point of the lubricant. In distinction from other soaps, in particular calcium base soaps, stearate and oleostearates of aluminum readily dissolve in mineral oils in all concentrations. E.E.B.

**N66-11094** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SYNTHESIS AND TECHNOLOGY OF PRODUCTION OF MULTICOMPONENT ADDITIVE VNII NP-360 TO MOTOR LUBRICATING OILS**

V. N. Monastyrskiy, A. A. Fufayev, and M. S. Perel'miter. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 204-212 refs (See N66-11076 02-15)

The synthesis and technology for the production of multicomponent additives for motor lubricants are discussed for barium alkylphenolate, zinc dialkylphenyldithiophosphate, and dialkylphenyldithiophosphoric acid. The barium alkylphenolate possesses good washing properties and the zinc dialkylphenyldithiophosphate has good anticorrosive and antioxidant properties. A combination of these two additives was recommended for further test on full-scale engines as a result of preliminary testing. The combination of the two additives passed short-term and prolonged stand tests on different engines and operational tests on diesel locomotive engines and tractor motors. Results showed higher effectiveness of this combination over additives presently used. E.E.B.

**N66-11104** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PHOSPHOROUS-ORGANIC COMPOUNDS REDUCING WEAR DURING FRICTION. MECHANISM OF THEIR ACTION**

P. I. Sanin and A. V. Ul'yanova. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 313-327 refs (See N66-11076 02-15)

The thermal decomposition of trioctadecylphosphite ( $C_{18}H_{37}O)_3P$ , tributylphosphite ( $C_4H_9O)_3P$ , and tributyltrithiophosphite ( $C_4H_9S)_3P$  were investigated. A diagram of the apparatus used for the decomposition is given, and the experimental procedure is described, including the procedures for quantitatively determining the decomposition products. These were phosphorous acid, phosphine, and octadecylene in the case of trioctadecylphosphite; phosphorous acid, phosphine, and butylene in the case of tributylphosphite, and phosphorous acid, phosphine, butylene, and hydrogen sulfide in the case of tributyltrithiophosphite. The percentage of recovery of all of these decomposition products in relation to theoretical recoveries from the reaction equations are given. Some experiments conducted in the presence of metals showed that metals can catalytically affect the decomposition initiating it at lower temperatures, and making the reaction proceed with greater speed once started. In addition the phosphine formed may react with some of catalyst forming metal phosphides. L.S.

**N66-11105** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**NEW METHODS AND RESULTS OF INVESTIGATION OF ANTIWEAR AND ANTIFRICTION PROPERTIES OF LUBRICATING MATERIALS**

G. V. Vinogradov. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 328-344 (See N66-11076 02-15)

Friction experiments with steel ball bearings were conducted in a vacuum friction machine for investigating the antiwear and antifricition properties of various lubricating materials. Gas media of different compositions can be blown through a chamber filled with lubricant in which the bearings are tested. A diagram of the apparatus is shown. Air, oxygen, and inert gases are blown through the lubricants, and frictional forces are determined at various loads. It is shown that in the absence of oxygen and oxygen-containing compounds hydrocarbon oils constitute an ineffective or little effective lubricating media for the boundary conditions defined. Oxygen dissolved in petroleum oils and products of their oxidation appear to play the most important role as a natural additive to lubricating oil, preventing the seizing of steel under boundary friction. L.S.

**N66-11106** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INVESTIGATION OF MECHANISM OF REACTION OF TRIBUTYLTRITHIOPHOSPHITE IN HYDROCARBON MEDIUM LAYERS OF COPPER BY USING RADIOACTIVE INDICATORS**

M. M. Kusakov, P. I. Sanin, E. A. Razumovskaya, A. V. Ul'yanova, and A. P. Dekartov. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 345-356 refs (See N66-11076 02-15)

The reaction mechanism of tributyltrithiophosphite with copper films in a hydrocarbon medium (naphthene-paraffin oil fraction MS-20) was investigated by means of radioactive tracers. The marking of the sulfur, phosphorus, or carbon atom of the organic molecule makes it possible to differentiate the action of these atoms, thereby clarifying the role of the hydrocarbon radical containing these atoms. Curves portraying the thickness of the layers formed by combination of the several labeled tributylphosphite compounds with respect to time (at constant temperature) are given. The kinetic studies support earlier results obtained for the thermal decomposition of tributyltrithiophosphite. L.S.

**N66-11107** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ANTISCORING ADDITIVES TO OILS FOR AUTOMOBILE TRANSMISSIONS AND MECHANISM OF THEIR ACTION**



- \* I. E. Vinogradov, Ye. I. Petyakina, and F. Ya. Shames *In its Additives to Oils and Fuels* 6 Apr. 1965 p 357-371 refs (See N66-11076 02-15)

Additives used in automobile transmission oils for lowering of friction and wear were tested for their antiscoring action on steel plates kept for three days at 120°C under oil samples containing the test additives. The plates were then washed in a solvent and kept for seven days in an atmosphere of humid air in an exsiccator. Corrosion was determined by the increase of weight in the plates after the test. The content of active element in the additive, the percent of additive in the oil after testing, the amount of steel corrosion, and other characteristic data are tabulated for each additive tested, along with the structural formula. The additives tested were organic compounds of sulfur, halides, phosphorus, and nitrogen; various oxidized and sulfurous compounds of molybdenum, tungsten, and zinc; and plumbic soaps. Several graphs showing the antiscoring properties of some of the additives are depicted, and the test results are discussed. L.S.

**N66-11108** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INFLUENCE OF CATALYST OF OIL OXIDATION ON ANTICORROSIVE EFFECTIVENESS OF ADDITIVES CONTAINING VARIOUS FUNCTIONAL GROUPS**

K. S. Ramyya and R. Kh. Sil's *In its Additives to Oils and Fuels* 6 Apr. 1965 p 372-380 refs (See N66-11076 02-15)

The effectiveness of organic metallic salts as oxidation catalysts in oil were studied. Experiments were conducted in which lead plates were immersed in oil, with a gaseous stream of oxygen flowing through the oil, thereby oxidizing (or corroding) the lead plate. The corrosive effectiveness is determined by measuring loss of weight in the lead plates after a period of time, with the oil being kept at a predetermined temperature. Results are depicted graphically for the influence of copper stearate, iron oleate, cobalt naphthenate, copper-iron, and copper cobalt on the corrosion of lead in two different base oils. Several other experimental variations of conditions and additive ingredients to the oils are also given. In general, it was shown that organic salts of metals accelerate the corrosion of the lead plates when the salts are dissolved in the oil, due to their catalytic action on oxidation in the oil. In other similar experiments it was indicated that additives containing anticorrosive compounds are not very effective in the presence of the organic metal catalysts. L.S.

**N66-11109** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**MECHANISM OF ACTION AND EFFECTIVENESS OF ADDITIVES INCREASING LUBRICATING ABILITY**

G. I. Fuks *In its Additives to Oils and Fuels* 6 Apr. 1965 p 381-400 refs (See N66-11076 02-15)

A review of literature data on oil additives is presented along with an analysis of the data in an effort to determine the mechanism of action and effectiveness of additives added to oil for the purpose of increasing the lubricating properties of the oil. Discussed are oil viscosity, friction, interaction of molecules at the boundary layer between oil and metal surface, pressure and temperature effects, static and kinetic friction effects, and boundary layer thickness effects. Several graphs and tables relating these parameters are presented. The relationship of some of these factors to the number of atoms in the hydrocarbon chain of the additive used, is also discussed. L.S.

**N66-11110** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**USES OF ANTIOXIDANT ADDITIVES TO POWER ENGINEERING OIL—NEW IN THEORY AND PRACTICE**

K. I. Ivanov, Ye. D. Vilyanskaya, and A. Luzhetskiy *In its Additives to Oils and Fuels* 6 Apr. 1965 p 401-413 refs (See N66-11076 02-15)

A review of the inhibiting influence of antioxidant oil additives is presented, with emphasis on the chemical kinetic mechanisms of the inhibitors. A table classifying known retarders of auto-oxidation in petroleum oils is given, along with a chain diagram showing the reaction mechanism of auto-oxidation as initiated by several inhibitors. The advantages of using mixtures of antioxidants is discussed, and tests were conducted with various mixtures of the compounds in power engineering oils. A table illustrating the influence of these mixtures on the stability of the power engineering oils is given. It is seen that different chemical structures of the antioxidants inhibit the rate of auto-oxidation unequally. The differences in the retardant action of the inhibitors is due to the different kinetic path that their free radicals take in interacting with other molecules. L.S.

**N66-11111** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INFLUENCE OF BASIC TYPES OF ADDITIVES ON OPERATING PROPERTIES AND OXIDATION OF OILS IN AN INTERNAL COMBUSTION ENGINE**

A. V. Druzhinina, T. A. Tsiguro, and V. F. Filipov *In its Additives to Oils and Fuels* 6 Apr. 1965 p 414-424 refs (See N66-11076 02-15)

The changes undergone by oils during their use in an internal combustion engine with and without the addition of additives to the oil were studied in an effort to clarify the mechanism of action of the additives on the oxidation process. Barium para-tert-octylphenolate proved to be the most effective additive of those investigated. It was shown that the oxidation of oil passes through a stage of hydrogen peroxide formation. The dynamics of the accumulation of peroxides in the oils containing additives were distinguished from oils not containing additives by measuring the peroxide number of the oil. The influence of several additives on the change in peroxide number in tested oils is graphically depicted. Other graphs are also given showing the influence of additives on the changes in acidity, carbonyl content, and ester numbers in the tested motor oils. The test results are tabulated, and the efficiencies of the additives of varying compositions are compared. L.S.

**N66-11112** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**COMPLEX OF METHODS TO APPRAISE THE EFFECT OF ADDITIVES ON THE WORKING PROPERTIES OF MOTOR OILS**

K. K. Papok, A. P. Zarubin, B. S. Zuseva, V. P. Danilin, G. V. Zakharov et al *In its Additives to Oils and Fuels* 6 Apr. 1965 p 426-441 refs (See N66-11076 02-15)

Laboratory methods were developed for rapidly appraising the working properties of oils and additives. The complex of methods include micro-methods, tests on model installations, and tests on one cylinder models. With the micro-methods, the fractional composition and thermal properties of a 10 ml oil sample can be determined; with the model installations the washing and crankcase properties of 0.5 liter of oil can be evaluated; and with the one-cylinder model, lacquer deposition and corrosion properties can be determined with 2.5 liters of oil. In the last method an oil and additive test can be coordinated to evaluate the scale forming ability of oil in combination with fuel. Each of the methods is discussed in detail, and tabulated experimental data are given showing the changes in the working properties of different oils under the effect of additives as determined by the above methods. Comparison of results obtained by these methods with tests run on full-scale motors shows good coordination. L.S.

**N66-11113** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**RADIOTRACER METHODS OF RESEARCH OF FUNCTIONAL PROPERTIES OF OILS WITH ADDITIVES**

Yu. S. Zaslavskiy, G. I. Shor, R. N. Shneyerova, F. B. Lebedeva, I. A. Morozova et al. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 442-450 refs (See N66-11076 02-15)

A method of studying electrokinetic processes and the mechanism of the dispersion action of additives in motor oils by using radioactive tracers is described, and a schematic diagram of the experimental apparatus is shown. The amount of deposition can be determined by beta-counting. A diagram of the electrophoresis of marked soot in motor oil AS-5 containing additive vnii np-354, recorded from readings of the upper beta-counter when 1000 v was supplied to its foil, is shown. Other curves are given to depict the results of determining the lacquer deposition ability of various oils and additives. In addition the evaluation of the chemical activity of antiburr additives to oils using the radioactive tracer method is discussed, and test data for an oil containing additive is tabulated. Curves depicting the results of investigating the wear properties of oils with chemically active antiburr additives on a friction machine are also given. L.S.

**N66-11114** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**A LABORATORY STUDY OF THE ANTIOXIDATION EFFECTIVENESS OF MOTOR-OIL ADDITIVES**

K. S. Ramaya, M. S. Borovaya, and R. Kh. Sil's. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 451-457 (See N66-11076 02-15)

A comparison is made of three methods used to determine the antioxidation effectiveness of motor oil additives. In the first method, oxidation proceeds at a temperature of 250°C under conditions of free diffusion of atmospheric oxygen and free vaporization of volatile oxidation products as well as the light fractions of the oil itself. The criterion for the oxidation rate is the time necessary to obtain a residue consisting of 50% lacquer (a product of the oxidation polymerization and condensation) not soluble in light gasoline, and 50% soluble lacquer. The second method allows oxidation for 50 hrs at 200°C under conditions of free access to atmospheric oxygen, but prevents the free vaporization of the oil and the products of its oxidation. The criteria for oxidation rate are the increase in oil viscosity and the amount of oxidation product sediments not soluble in light gasoline. In the third method oxidation is conducted in a closed system at 175°C with oxygen at atmospheric pressure. The oil undergoes no change, and the oxidation rate is determined on the basis of the time needed to absorb 0.8 ml of oxygen by 1 gram of oil. Data from investigations of six oil samples are tabulated and the results discussed. R.N.A.

**N66-11115** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**NEW METHOD OF EVALUATING THE EFFECTIVENESS OF ANTIBURR ADDITIVE ACTION IN OILS AND FUELS**

K. I. Klimov, A. V. Vilenkin, and G. I. Kichkin. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 458-466 refs (See N66-11076 02-15)

A friction machine with a pair of crossing cylinders and periodic contact of surfaces was developed to evaluate antiburr properties of lubricating materials. The necessity is shown, in comparative appraisals of antiburr properties of oils with additives on friction machines, of modeling the test conditions by slip speed, contact periodicity, and temperature in a wide interval of their changes. A method was developed for the comparative appraisal of antiburr properties of lubricating materials under conditions simulating the real working conditions of oil. Antiburr properties of certain oil products were investigated

in pure form and with additives. The instrument and appraisal method used are shown to be highly sensitive and exceed the sensitivity of other methods and instruments. R.N.A.

**N66-11116** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE EFFECT OF LUBRICATING MATERIALS AND THEIR ADDITIVES ON FORMATION OF PITTING**

M. D. Bezborod'ko and G. S. Krivosheyn. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 467-476 refs (See N66-11076 02-15)

An investigation is presented on the effect of lubricants and their additives on pitting formation. It is shown that antipitting properties of lubricating materials can be quickly and reliably estimated on a four-ball friction machine adjusted for work in conditions of rolling. The ability of lubricants to slow down the development of pitting depends on their viscosity and chemical composition. Additives introduced in lubricating materials, depending on their composition and concentration, can increase or decrease pitting development. R.N.A.

**N66-11117** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE EFFECT OF OIL ADDITIVES ON CORROSIONAL WEAR OF BEARING ALLOYS**

K. S. Ramaya and V. S. Zavel'skiy. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 477-488 refs (See N66-11076 02-15)

An investigation was conducted to determine the anticorrosion properties of the oil additives tsiatim-330 (naks), tsiatim-339, and DF-1, on the plumbous alloys SOS6-6 used in automobile engine bearings. The naks additive contains the anticorrosive component sulfurized oil and a washing component cobalt naphthenate. The plumbous alloy contains 88% lead, 6% tin, and 6% antimony. Oil samples containing the additives and alloy samples were exposed to various concentrations of oleic acid. In acid concentrations up to 1 mg KOH, corrosion of the lead alloy was greater with the naks additive than with the additives tsiatim-339 and DF-1. But at higher acid concentrations the naks additive formed a more protective film on the lead alloy which increased in anticorrosion protection with an increase in acid concentration. However, under actual engine operating conditions, oil acidity rarely reaches these concentrations. Therefore, the naks additive is not recommended for use as an anticorrosive component in motors with plumbous alloy SOS6-6 bearings. From the data, additives of the type DF-1, in which the anticorrosive component is of the thiophosphoric group, were shown to give the best protection to plumbous alloy bearings. R.N.A.

**N66-11118** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**METHOD OF APPRAISAL OF WORKING PROPERTIES OF INHIBITED INSULATING OILS**

K. I. Ivanov, R. A. Lipsteyn, A. Ya. Mikhel'son, and A. A. Luzhetskii. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 489-498 refs (See N66-11076 02-15)

A new bench method of determining the working properties of transformer oils was developed. As a result of numerous tests on a large number of developmental types of oils by this method, the following oils were introduced or recommended for introduction: oil of phenol purification from eastern oils (sulfur less than 0.6%) with 0.2% additive Topanol-O (VTU NP-30-59), oil hydropurified from eastern oils (sulfur less than 2%) without additives, oil of acid-alkaline purification from Anastas'insk oil with additives, and oil from Emba oils purified by gasiform SO<sub>3</sub> with 0.2% additive Ionol. R.N.A.

- **N66-11119** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**CALCULATING THE NECESSARY CONCENTRATIONS OF NEUTRALIZING ADDITIVES IN MOTOR OILS**  
 V. D. Reznikov, N. G. Puchkov, and M. S. Borovaya *In its Additives to Oils and Fuels* 6 Apr. 1965 p 499-511 refs (See N66-11076 02-15)

A method was developed for calculating the necessary concentrations of neutralizing additives in motor oils when shifting to fuels with large sulfur contents. The calculations are dependent on the sulfur content of the fuel and a number of constructive and exploitational parameters of the motor. The necessary concentrations of the additive *vnii np-360* were determined for a D-38 motor operating with fuels of varying sulfur content. The calculations obtained closely coincided with those obtained by experimentation. R.N.A.

- N66-11120** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**METHOD OF DETERMINING REQUIREMENTS FOR QUALITY OF LUBRICATING OILS FOR TRACTOR MOTORS**  
 S. G. Arab'yan *In its Additives to Oils and Fuels* 6 Apr. 1965 p 512-522 refs (See N66-11076 02-15)

A method is presented for selecting tractor motor lubricating oils in which the motor design features and operating conditions are considered. The crankcase oils are classified on the basis of tests by special motor installations which determine the exploitational properties of the oils. From the test results, the oils are given a point rating according to quality and placed in one of four groups corresponding to various operating conditions of motors. With this system, not only can the quality of oil needed for a particular engine be determined, but also the type of oil needed for a particular working condition of a particular motor can be selected. R.N.A.

- N66-11121** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**TESTS OF OILS FROM SULFUROUS CRUDES WITH DIFFERENT ADDITIVES**  
 N. G. Puchkov, M. S. Borovaya, A. A. Deryabin, and G. P. Belyanchikov *In its Additives to Oils and Fuels* 6 Apr. 1965 p 524-534 refs (See N66-11076 02-15)

The results of laboratory and motor tests on a number of native oil additives are compared with certain foreign oil additives to determine the possibility of producing motor oils of the series I, II, and III (oils for normal, heavy, and very heavy working conditions). Results show that available native additives can be used to produce motor oils corresponding to foreign oils of the premium type and series I. Development and application of corresponding additives for oils of series II and III, necessary for new promising motors, are required. Certain native additives used for oils of series O and I are comparable in quality to corresponding imported additives, but it is necessary to establish optimum combinations of these additives and select their concentrations in oils. More work is needed on improving the quality of additives for oils of series I. Work is also needed on decreasing the content or changing the character of metalorganic compounds in additives to decrease carbon deposition in motors, and to improve the antioxidation properties of additives. R.N.A.

- N66-11122** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**METHODS AND RESULTS OF TESTS OF OILS WITH ADDITIVES ON DIESEL ENGINES OF KOLOMENSKIY FACTORY**  
 L. S. Ryazanov *In its Additives to Oils and Fuels* 6 Apr. 1965 p 535-543 ref (See N66-11076 02-15)

Procedures and results are presented of tests on oils with anticorrosive additives produced from sulfur bearing crude oil. The tests were performed in high-forced diesel engines operating on low sulfur fuels. The oils performed satisfactorily but their quality needs improvement. Requirements for oils and additives are discussed. R.N.A.

- N66-11123** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**TESTS OF ADDITIVES TO OIL ON A 2D100 MOTOR OF A DIESEL LOCOMOTIVE WHILE OPERATING ON SULFUR-BEARING FUEL**

B. N. Strunge and N. P. Sinenko *In its Additives to Oils and Fuels* 6 Apr. 1965 p 544-555 (See N66-11076 02-15)

A number of oil additives were tested in a 2D100 diesel engine operating with a sulfur bearing fuel. Test procedures and results are discussed. R.N.A.

- N66-11124** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**RESULTS OF MOTOR TESTS OF ADDITIVES DEVELOPED BY THE INSTITUTE OF PETROCHEMICAL PROCESSES OF THE ACADEMY OF SCIENCES OF THE AZERBAIDZHAN SSR (INKhP AN AZERB SSR) FOR THE IMPROVEMENT OF OPERATIONAL PROPERTIES OF FUELS AND OILS**

V. Ye Bashayev *In its Additives to Oils and Fuels* 6 Apr. 1965 p 556-563 (See N66-11076 02-15)

A discussion is presented on two new additives for improving the operational properties of fuels and oils. The first is a sulfonate detergent additive, SB-3, and the other an antiwear additive, BFK-1, which is a barium salt product from the condensation of alkylphenol by formaldehyde. A 10% addition of SB-3 to oil prolongs engine life and ensures full mobility of piston rings, and cleanliness of diesel engines and carburetor motors. The additive BFK-1 also ensures prolonged diesel engine life. It is recommended that the SB-3 and BFK-1 additives be mixed in a 4 to 1 ratio for optimum improvement of diesel oil performance. R.N.A.

- N66-11125** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**EXPERIMENT IN USING OIL ADDITIVES FROM SULFUR-BEARING CRUDES IN DIESEL LOCOMOTIVE DIESEL ENGINES**

I. S. Zelenetskaya *In its Additives to Oils and Fuels* 6 Apr. 1965 p 564-574 (See N66-11076 02-15)

Operational tests were conducted on oils from sulfur bearing crudes with different additives in diesel locomotive engines. On the basis of test results, DS-11 oil with an 8% *vnii np-360* additive is recommended for use with diesel fuel containing up to 1% sulfur in diesel locomotive engines of the 2D100 type. The additives *tsiatim-339p* and *aznii-7* performed poorly with 2D100 diesel engines using fuel with a sulfur content of 0.8 to 1.0%. There was evidence of increased scale deposits, scorched oil rings, and increased wear. R.N.A.

- N66-11126** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**THE EFFECT OF MOTOR OIL ADDITIVES ON PITTING (POINT BREAKING OFF) OF HYDRAULIC LIFTERS**  
 O. S. Oblyukhov, V. V. Protasov, and R. A. Trubinskaya *In its Additives to Oils and Fuels* 6 Apr. 1965 p 575-586 (See N66-11076 02-15)

Pitting of hydraulic lifters is caused by the washing components of oil additives which promote corrosional fatigue of metal. The most effective additive for preventing pitting is DF-11, dithiophosphate of zinc, which is prepared with primary octyl alcohol (2-ethylhexyl) in a mixture with isobutyl alcohol. This additive is introduced into oil in a quantity of 2%, calculating the content of zinc and phosphorous in oil at nearly 0.1%. To obtain satisfactory washing properties in oil it is necessary to introduce sulfonate or alkylphenol additives. Satisfactory washing, antiwear, and anticorrosive oil properties can be obtained with an additive composition of 3% low ash sulfonate AzNII with 2% DF-11, and 3% sulfonate additive SB-3 with 2% DF-11. Using 24 and 50 hour motor tests, the additives which best prevent pitting can be selected and at the same time a comparative appraisal can be made of the quality of metal used in the hydraulic lifters. R.N.A.

**N66-11127** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**METHOD AND RESULTS OF STAND TESTS OF TRANSMISSION OILS WITH DIFFERENT ADDITIVES**

O. S. Obelukhov, E. N. Devyatkin, and A. V. Berenfel'd. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 587-595 (See N66-11076 02-15)

Bench tests were conducted for automobile transmission oils. The oils were tested in conditions simulating operation at different speeds, when the transmission of all the torque of the motor was to one drive axle, and where each stage of tests was preceded by a stage of rolling. The procedures are given and the results tabulated. These include antiwear, anti-burr, and anticorrosive properties; and also stability and foam characteristics. Additives were considered, and certain oils are recommended. C.T.C.

**N66-11128** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**RESEARCH ON EFFECTIVENESS OF ADDITIVE TSATIM-339 DURING PROLONGED OPERATION OF HIGH SPEED AND FORCED SHIP DIESEL ENGINES ON SULFUR-BEARING FUELS AND OILS**

V. P. Korotnenko. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 596-603 (See N66-11076 02-15)

The effectiveness of the additive tsatim-339 in prolonging the operation of ship diesel engines operating on sulfur bearing fuels and oils was investigated. Diesel engines were operated on sulfur bearing diesel fuel of brand C (GOST 305-58) and lubricating oils from Baku crudes with 3% additive tsatim-339, and lubricating oils from sulfur bearing crudes with the same additive concentration. Engine life was effectively prolonged by the additive in lubricating oils from Baku crudes. However, in the lubricating oils from sulfur bearing crudes, tsatim-339 was ineffective in neutralizing the harmful effects of combustion products from the sulfur bearing fuels and oils. R.N.A.

**N66-11129** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE EFFECT OF VISCOSITY OF ADDITIVES ON OPERATIONAL PROPERTIES OF OILS**

Ye. G. Semenido, V. I. Sharapov, and N. V. Shchegolev. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 604-617 refs (See N66-11076 02-15)

The influence of viscosity additives on the antiwear properties of oil was investigated. The antiwear properties of oils thickened by polyisobutylene exceed those of oils prepared by usual methods. Sulfur bearing oils are better in this respect than Baku oils. Several multifunctional additives were studied for their effect on antiwear properties of oil and of these the best were found to be aznii-8, vnii np-361, and vnii np-361a.

The last two additives are identical in chemical nature and differ only in their washing and polyfunctional components. Data on the antiwear properties of lubricating oils, obtained by the method of radioactive isotopes, agree well with the results of 60-hour bench tests of ASZ<sub>p</sub>-10 oil thickened by polyisobutylene with additive vnii np-361a, and on AKZ<sub>p</sub>-10 oil with additive aznii-8. R.N.A.

**N66-11130** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ADDITIVES TO LIQUID FUELS FOR GAS TURBINE INSTALLATIONS, PREVENTING DEPOSITS OF ASHES AND VANADIUM CORROSION**

R. A. Lipshteyn, S. E. Khaykina, A. S. Avetisyan, and T. A. Blagova. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 619-630 (See N66-11076 02-15)

Static and dynamic tests were conducted on 20 substances to determine their effectiveness as fuel additives in preventing ash deposition in the flow-through area of gas turbines and vanadium corrosion of turbine blades. The most effective were montmorillonite, kaolin, dolomite, magnesium oxide, and sulfate. The tests were conducted with a gas turbine installation with a capacity of 1500 hp on motor fuels DT-1 and DT-2, and on sulfurous black oils 40 and 60. Motor fuel containing around 0.002% vanadium pentoxide causes noticeable corrosion of the steels EYaT, EI405, and EI612 at temperatures of 700° C and above. The normal operation of a gas turbine on black oil does not exceed 48 hours because of the fast jamming of the flow-through part of the turbine by deposits. According to preliminary data, kaolin, added in a 0.2% wt concentration to black oil, lowers jamming and in motor fuels prevents vanadium corrosion of steel at a gas temperature of 700° C. R.N.A.

**N66-11131** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SOME DATA ON THE USE OF ANTICORROSIVE ADDITIVES TO RESIDUAL FUELS CONTAINING VANADIUM AND SULFUR**

V. G. Nikolayeva, A. Ya. Dukhnina, B. I. Komarov, and G. I. Levinson. *In its Additives to Oils and Fuels* 6 Apr. 1965 p 631-641 (See N66-11076 02-15)

Results are presented of research conducted on the corrosion aggressiveness of ashes of different crude oils and on the influence of magnesium, silicon, and aluminum anticorrosive additives in residual fuels containing vanadium and sulfur. Results show that compounds of magnesium and silicon are the best for use as anticorrosive additives during the burning of sulfurous residual gas turbine fuels containing vanadium. R.N.A.

**N66-11265#** United States Steel Corp., Monroeville, Pa. Applied Research Lab.

**DEVELOPMENT OF A K<sub>IC</sub> STRESS-CORROSION TEST SPECIMEN**

S. T. Rolfe 1 Mar. 1965 30 p refs  
(Contract Nobs-88540)  
(S-23304; AD-616931)

A study was made to develop a K<sub>IC</sub> stress-corrosion test that would be suitable for investigating the phenomenon that the effective fracture toughness of certain materials may be reduced if a flaw in the material can extend by stress corrosion to a critical size. The results of the study indicate that by appropriate modification, the standard K<sub>IC</sub> slow-bend fracture-toughness test can be used to demonstrate the effect of stress corrosion on fracture toughness. The modification consists of notching the specimen face so that plane-strain fracture can be obtained in relatively small specimens of tough materials. The fatigue-cracked area is surrounded by the appropriate corrosive environment and the specimen is dead-weight-loaded as

- a cantilever beam Preliminary results on a 12Ni-5Cr-3Mo maraging steel (yield strength of about 175 ksi and Charpy V-notch energy absorption of about 35 ft-lb) have shown that this steel failed by plane-strain fracture at values ranging from 0.8  $K_{IC}$  at 10 hours to 0.3  $K_{IC}$  at 400 hours when the fatigue crack was exposed under stress to synthetic sea water. To date, similar failures have not been observed in the 5Ni-Cr-Mo-V experimental HY-130/150 steel after more than 500 hours in test. Author (TAB)

**N66-11372#** Rock Island Arsenal Lab., Ill. Research and Engineering Div.

**PERFORMANCE EVALUATION OF CUTTING FLUIDS**

Lanny D. Wells Jun. 1965 27 p refs

(RIA-65-1491; AD-620158)

An investigation into the effects of cutting fluids upon tool life, cutting forces and various theoretical tool-chip relationships has been conducted for the purpose of developing a test procedure for cutting fluid performance evaluation. Variable speed tool life testing under carefully controlled conditions, with complete tool failure as the end point of tool life, was found to give the most satisfactory results. Some correlation was found to exist between tool life and the Falex extreme pressure test and some theoretical relationships. This correlation appears to be of academic interest only and is of little practical value because of the inherent variation in most machining operations. Author (TAB)

**N66-11492#** Oak Ridge National Lab., Tenn.  
**ALUMINUM AND TITANIUM CORROSION IN SALINE WATERS AT ELEVATED TEMPERATURES**

E. G. Bohlmann and F. A. Posey [1965] 28 p refs

(Contract W-7405-ENG-26)

(ORNL-P-1430)

Studies of electrochemical aspects of the corrosion of aluminum alloys 5454 and 6061 were conducted in 1 M NaCl at 150° C in a titanium dynamic loop facility. Corrosion rates were followed with time by measurement of the polarization resistance of the specimens. The results show that the 5454 alloy is superior to the generally recommended 6061 alloy in corrosion resistance under all conditions studied. Polarization curves of the alloys were measured under a variety of conditions in order to determine the nature of the difference in corrosion properties. The results are generally similar to those obtained by other workers at lower temperatures, except for certain complications which appear mainly at the higher temperature of this study. Comparison of polarization curves of the 5454 and 6061 alloys shows that the rate of the cathodic hydrogen-evolution reaction on the 6061 alloy is considerably greater than that of the 5454 alloy. The enhanced rate of the cathodic process on the 6061 alloy accounts for its greater corrosion rate at any pH and for its susceptibility to pitting attack. Catalysis of the cathodic process on the 6061 alloy may be attributable to its copper content. Author

**N66-11528#** Springfield Armory, Mass.  
**TEST RESULTS ON FALOX PINS COATED BY THE PLASMA-ARC PROCESS**

Francis X. Hasson 30 Jul. 1965 25 p refs

(SA-TR18-1096; AD-621064)

Coatings of nickel-alumina, molybdenum, tungsten, alumina, tungsten carbide-cobalt, stainless steel, and zirconia applied to Falex pins by the plasma-arc process were tested for wear resistance. The tungsten carbide-cobalt, the tungsten, and the molybdenum coatings showed unusually good wear characteristics comparable to dispersions of diamond, zirconia, and thoria in chromium electroplate formed at high current densities. The coefficients of friction appeared to be somewhat higher in the plasma-arc coatings. This may be

due, however, to the initial roughness of the surfaces tested. The other plasma-arc coatings, i.e., nickel-alumina, alumina, stainless steel, and zirconia either flaked, wore off, or galled under test. Procedures are described and results are discussed.

Author (TAB)

**N66-11700#** Oak Ridge National Lab., Tenn. Metals and Ceramics Div.

**PROCUREMENT AND QUALITY EVALUATION OF Nb-1% Zr STOCK FOR BOILING ALKALI METAL CORROSION STUDIES**

T. K. Roche Aug. 1965 16 p

(Contract W-7405-ENG-26)

(ORNL-TM-1179)

Tubing, plate, and bar stock of Nb-1% Zr were procured for evaluation in boiling alkali metal systems. Costs for this material, together with the results of evaluating its quality upon receipt from the various vendors, are presented. Author

**N66-11728#** Mechanical Technology Inc., Latham, N. Y.  
**PRELIMINARY STUDY OF THE LIQUID METAL LOOP AND TEST RIG FOR PHASE II OF THE INVESTIGATION OF LIQUID METAL LUBRICATED BEARINGS AND ROTOR-BEARING DYNAMICS**

W. D. Waldron and E. B. Arwas 23 Feb. 1965 31 p refs

(Contract AT(30-1)-3363)

(MTI-64TR72, rev.-2; NYO-3363-1)

The results of a study of the mercury loop and the rotor-bearing test rig for use in a liquid metal lubricated bearing and rotor-dynamics program are presented. The modification of the mercury loop for conversion to alkali metal, with NaK selected as the test fluid, is discussed. NSA

**N66-11819#** Pratt and Whitney Aircraft, Middletown, Conn.  
**SINGLE FILM JOURNAL BEARING TESTS IN WATER**

B. Weinberg 30 Jul. 1965 17 p refs

(Contract AT(30-1)-2789)

(TIM-916)

This report describes a series of tests conducted with fluid-film bearings as part of a program for developing a shaft-bearing system for liquid metal pumps to be used in the SNAP-50/SPUR powerplant. Hydrodynamic, hydrostatic, and hybrid type bearings were tested using water to simulate the low kinematic viscosity condition of lithium. The test unit, which was basically a shaft supported by a conventional single deep-groove ball bearing at one end and the test bearing at the other, was also operated to simulate the dynamic conditions of a similar test unit which was operated with lithium at 600° F. Author

**N66-11852#** Battelle Memorial Inst., Columbus, Ohio.  
**PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING SEPTEMBER 1965**

Russell W. Dayton and Stan J. Paprocki 1 Oct. 1965 31 p refs

(Contract W-7405-ENG-92)

(BMI-1745) Available From AEC, Oak Ridge, Tenn.: \$0.75

Research having the general objective of providing support to the Atomic Energy Commission's overall reactor development program is reported. Presented are data on: reactor materials and components, fuel development studies, radioisotope and radiation applications, coated-particle fuel materials, corrosion studies of the fluidized-bed fluoride-volatility process, and the gas-cooled reactor program. Cited are studies on the effect of irradiation on the mechanical properties of Type-347 stainless steel; the effects of high burnup on  $UO_2$ -CeO<sub>2</sub> and  $UO_2$ -ZrO<sub>2</sub> fuels; radiation-induced formation of organometallic compounds with particular emphasis on organotin; and coated-particle preparation and characterization. S.C.W.

**N66-11939#** Bureau of Mines, Bartlesville, Okla.  
**VARIABLES IN THE USE OF HOT-FINISHED MILD STEEL COUPONS FOR CORROSION INHIBITOR TESTING**

Jerry B. F. Champlin and Don R. Thompson 1965 21 p refs  
 Based on work done in cooperation with the State of Oklahoma (BM-RI-6696)

An accelerated testing procedure developed by the Bureau of Mines for evaluating commercially available corrosion inhibitors is described. Ultrasonic agitation of the corrodent solutions and the hot-finished mild steel test coupons was used to evaluate the effects of several variables on the effectiveness of two corrosion inhibitors. Small changes in the weight of the test coupons in both controlled and inhibited corrodents, before and after exposure, affected the precision and accuracy of the results. Minute amounts of oxygen in the systems were found to be causing the relatively large deviations in the corrosion developed in the controlled tests. Microscopic examination of the test coupons revealed that both surface preparation and internal strains resulting from fabrication methods materially affect corrosion behavior. Author

**N66-11959#** Columbia Univ., New York. Lubrication Research Lab.

**ESTABLISHMENT OF DIFFERENTIAL EQUATIONS FOR LOAD-DEFLECTION CHARACTERISTICS OF THIN ELASTIC LAYERS FOR APPLICATION TO COMPLIANT BEARINGS HAVING FLUID-FILM LUBRICATION**

V. Castelli Aug. 1965 25 p ref  
 (Contract Nonr-4259(06))  
 (Rept.-3; AD-471832)

The report contains a derivation of differential equations which, to any desired degree of approximation, relate directly the normal load and local deflection of a thin elastic layer. Three types of boundary conditions on one side of the layer are studied to represent situations of interest in compliant surface lubrication. Author (TAB)

**N66-12016#** Coating and Chemical Lab., Aberdeen Proving Ground, Md.

**EFFECT OF PAINT VAPORS ON CADMIUM PLATED STEEL**  
**Final Report**

William H. Deaver 1 Oct. 1965 7 p refs  
 (CCL-187; AD-622280)

Studies to determine the cause of cadmium corrosion encountered in electronic vans showed the curing of alkyd resin enamels in a closed system can create an atmosphere corrosive to cadmium plated steel. Proper curing and ventilation should prevent this occurrence. It is also possible that the incorporation of some acid reactive pigment, such as zinc oxide, in alkyd enamels would also eliminate this type corrosion. Investigation of nine additional coatings representing different types of coating vehicles indicated that epoxy, vinyl, nitrocellulose-alkyd and nitrocellulose-acrylic vehicles will not create this corrosive atmosphere. Author (TAB)

**N66-12106#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**EFFECT OF OPERATING CONDITIONS AND GAP SIZE IN THE CONNECTION OF PLASTIC AND METAL DETAILS ON THE MAGNITUDE OF THE FRICTION COEFFICIENT**

Yun-Tsyu Shen 26 Aug. 1965 9 p Transl. into ENGLISH from Izv. Vysshikh Uchebn. Zavedenii., Mashinostro. (Moscow), no. 3, 1963 p 82-86  
 (FTD-TT-65-737/1+2+4; AD-621003)

The report discusses operational and geometric factors affecting the workability of polyamide slide bearings. The given data is useful for constructors, introducing plastics into machine construction. TAB

**N66-12126\*#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**POTASSIUM CORROSION TEST LOOP DEVELOPMENT**  
**Quarterly Progress Report No. 7, Jan. 15-Apr. 15, 1965**

E. E. Hoffman, ed. [1965] 107 p refs  
 (Contract NAS3-2547)

(NASA-CR-54735) CFSTI: HC \$4.00/MF \$0.75 CSCL 14B

The evaluation of Component Evaluation Test Loop II was completed. The loop components performed well and metallographic examination and chemical analyses of loop tubing indicated that no corrosion occurred during the 2650 hour test at 2000° F with liquid sodium. All subassemblies of the prototype corrosion loop were completed. Fabrication of alkali metal purification and transfer system components was completed. The sodium for the primary circuit of the prototype loop was purified by hot trapping with zirconium foil and is ready for use. Calibration of prototype loop components including the partial pressure analyzer, refractory alloy thermocouples, flow-meter magnets, and pressure transducer was completed. The 2500 hour 2000° F refluxing potassium test to determine the compatibility of Mo-TZM alloy in the condensing region of a Cb-TZr alloy capsule was completed and evaluated. Weight change data indicate no significant compatibility problems. A second capsule test is being continued for a total of 5000 hours to determine the time effect on interaction of this three component system. R. N. A.

**N66-12142\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**ROLLING-CONTACT LUBRICATION STUDIES WITH POLYPHENYL ETHERS AT REDUCED PRESSURE**

Richard J. Parker, Erwin V. Zaretsky, and William J. Anderson Washington, NASA, Dec. 1965 19 p refs  
 (NASA-TM-X-56977; NASA-TN-D-3130) CFSTI: HC \$1.00/MF \$0.50 CSCL 11H

A modified five-ball fatigue tester was used to determine the relative lubricating characteristics in rolling contact of polyphenyl ethers and mineral oils. Test conditions were a race temperature of 300° F, a shaft speed of 4900 revolutions per minute, and a test duration of 6 hours with AISI M-50 balls. Measurements on the upper ball were made to determine the effects of reduced pressure, lubricant degassing, contact angle, and contact stress on wear. A four-ring polyphenyl ether (4P3E) exhibited several times more wear than a naphthenic mineral oil when the fluids were tested at pressures near their vapor pressures at 300° F. In tests at atmospheric pressure in an argon atmosphere, the 4P3E polyphenyl ether exhibited more wear than a paraffinic oil. Greater wear occurred when the 4P3E polyphenyl ether was tested at a pressure near its vapor pressure than in argon at atmospheric pressure with all other conditions equal. Increased wear at higher contact angles and higher contact stresses was accompanied by increased darkening of the 4P3E polyphenyl ether. Rolling-contact fatigue tests in the five-ball fatigue tester indicated that the fatigue life with a 5P4E polyphenyl ether at 300° F may be expected to be comparable to that with the mineral oils. The polyphenyl ethers appear to be inferior to the mineral oils in their ability to provide elastohydrodynamic lubrication. Author

**N66-12264\*#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**STUDIES OF ALKALI METAL CORROSION ON MATERIALS FOR ADVANCED SPACE POWER SYSTEMS**  
**Quarterly Progress Report No. 4, Mar. 26-Jun. 26, 1965**

R. W. Harrison [1965] 47 p refs  
 (Contract NAS3-6012)

(NASA-CR-54476) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

Influence of stress on corrosion behavior of an advanced refractory alloy in potassium and corrosion mass transfer effects in a stainless steel-niobium alloy-potassium system were

investigated. Two niobium-base alloy stress corrosion reflux capsules were heat treated for one hour at 2400° F. Since creep rate measurements indicated a faster rate at 2250° F than expected from pre-test uniaxial creep data, a temperature of 2100° F was selected to give the desired 5-10% creep strain for 500 to 2000 hr operation. With 430 hr test time accumulated, creep strain has reached 2-3%. Metallographic examination indicates no changes in one type of capsule (321SS), but two distinct layers, believed to be NbC and Nb<sub>2</sub>N, in the other (316SS). Gross sensitization and sigma phase occurred in the latter, and stress-rupture testing of Nb-1Zr specimens indicates the effects of carbon and nitrogen mass transfer. Post-test evaluation shows significant advantage of the Type 321SS capsule over the Type 316SS with respect to C and N transfer. M.W.R.

**N66-12375#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**POLYSILOXANES AS ANTIFRICTION AND ANTIWEAR ADMIXTURES TO PETROLEUM GREASES**

G. V. Vinogradov, N. S. Nametkin, and M. I. Nosov 18 Jun. 1965 13 p refs Transl. into ENGLISH from Neftekhimiya (USSR), vol. 3, no. 5, 1963 p 792-798 (FTD-TT-65-316/1+2+4; AD-621008)

The use of polysiloxanes in combination with petroleum oils to achieve high lubricating qualities was investigated, as well as finding petroleum oil components most effective for this purpose. The results show that: (1) In a narrow range, polyethylsiloxane concentrations can be highly effective antiwear and antifriction additions to petroleum oils. (2) In the use of remnant oil MK-22, the highest applicability with respect to polyethylsiloxanes are demonstrated by fractions (obtained by absorption distribution over silica gel), enriched with hydrocarbons with a small number of aromatic rings in the molecules. (3) Conditions for the appearance of high activity of polyethylsiloxanes at heavy friction conditions are preliminary training of friction surfaces in polyethylsiloxane solutions in open air and sufficiently high concentration of oxygen in the friction zone. The mechanism of antifriction and antiwear effects of polyethylsiloxanes are determined by chemical processes during friction, which are connected with the decomposition of polyethylsiloxane in the friction zone and with the oxidation processes taking place on the friction surfaces. R.R.D.

**N66-12509#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**FREE-CUTTING STAINLESS STEEL**

N. M. Pisarev and V. M. Kozhin 27 May 1965 5 p Transl. into ENGLISH from Soviet patent no. 155813 (Appl. no. 779510/22-2, 18 May 1962) 2 p (FTD-TT-65-487/1; AD-620079)

The object of the invention is a free-cutting stainless steel containing 0.35-0.45% carbon, 16-18% chromium, 1.5-2.5% nickel, 0.7-1.2% manganese and up to 0.5% silicon is distinguished by the fact that, in order to enhance the mechanical and anticorrosion properties, 0.7-0.9% molybdenum, 0.15-0.25% sulfur and 0.08-0.15% phosphorous are introduced. TAB

**N66-12537#** Shell Oil Co., Wood River, Ill. Research Lab. **STUDY OF HELICOPTER GEAR LUBRICATION** Quarterly Progress Report, Jun.-Aug. 1965

D. R. Bailey, S. J. Beaubien, J. E. Bevel, and D. E. Stuart [1965] 22 p refs (Contract N0w-65-0323-c) (QPR-2; AD-621916)

Studies of the effect of gear-tooth surface pretreatments on gear performance were continued. Two surface precoatings, one obtained with Parco lubrite solution and one with tri-

chloroacetic acid, were found to increase greatly the constant load gear fatigue life, the former consistently, and the latter under some conditions of operation. A 30% reduction in load with the untreated gears was necessary in order to achieve the same constant load life as obtained with Parco lubrite treated gears at 6400 rpm. In other experiments, improvement of the surface finish by lapping resulted in improvements in gear life of about two to four times that of the untreated gears, the greater improvement being a low speed. None of the pretreatments significantly affected the score load of a MIL-L-23699 oil. In break-in studies employing a loading schedule in which the load was increased stepwise, it was found that neither operation for a long prior period at low load nor elimination of the low-load steps had any significant effect on the eventual failure load, or the mode of failure. In tests with a synthetic base oil on the rotary contact simulator, in which various points on the gear tooth profile were simulated, immediate scoring occurred on the disks simulating the tips, and areas near the tips, of the pinion and gear addenda. In every case of scoring, the mating disks, representing the corresponding dedenda, had undergone considerable surface cracking and sometimes pitting. Between these extremities on the gear-tooth active profile no failures occurred. Author (TAB)

**N66-12595#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE GYROSCOPE IN GIMBAL SUSPENSION**

Yevgeniy Leopoldovich Nikolai 18 Aug. 1965 147 p refs Transl. into ENGLISH from the book "Girooskop v Kardanovom Podvese" Moscow, Izd. Nauka, 1964 136 p (FTD-TT-65-416/1+2; AD-620837)

Contents: Differential equations of motion of a gyroscope in a gimbal mount; Stability of the axis of a rapidly spinning gyroscope; Pseudoregular precession of a gyroscope acted on by a constant moment; The case of constant friction at the gimbal axes. The representative point method; Elementary cases of gyroscope motion in the presence of friction at the gimbal axes; Small oscillations of a balanced gyroscope in the presence of friction at the gimbal axes; Pseudoregular precession of a gyroscope in the presence of friction at the gimbal axes; Motion of a gyroscope in the presence of friction forces proportional to the normal components of the dynamic reactions; Present state of the theory of the astatic gyroscope in a gimbal mount. TAB

**N66-12606#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**RESOURCE INCREASED IN DOUBLE**

M. Gal'perin, G. Ushakov, and G. Vasil'chenko 26 Aug. 1965 10 p Transl. into ENGLISH from Grazhdanskaya Aviatsiya (Moscow), no. 8, 1964 p 28-29 (FTD-TT-65-723/1+2+4; AD-620974)

The general service life and time before first repair of piston type aircraft engines was almost doubled by improving the air flow of the cylinder, reducing cylinder temperature, improving lubrication and reducing load on pistons of main connecting rods. TAB

**N66-12735** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**BASIC PROBLEMS IN PREPARATION FOR BROAD APPLICATION OF ALUMINUM ALLOYS IN CONSTRUCTION**

S. V. Taranovskiy In its Bldg. Struct. from Aluminum Alloys 27 Jul. 1965 p 1-23 (See N66-12734 03-17)

Basic problems in the use of aluminum alloys for construction are examined. Discussions are included on the selection of brands of aluminum alloys and types of joints for building structures, the manufacture of semifinished aluminum alloy

products and structures, the corrosion resistance of aluminum alloys, and certain peculiarities of aluminum alloy structures with respect to calculating ultimate strains and stability. R.N.A.

**N66-12739** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**CORROSION RESISTANCE OF ALUMINUM ALLOYS IN BUILDING STRUCTURES**

Yu. N. Tikhenko and V. Ya. Flaks. *In its Bldg. Struct. from Aluminum Alloys* 27 Jul. 1965 p 99-132 refs (See N66-12734 03-17)

Corrosion data on aluminum alloys in building structures and the results of corrosion tests conducted on aluminum alloys under environmental conditions in metallurgical factories and in the atmosphere of an industrial city are presented. Corrosion losses in sheets of AMts-M, AMg6-M, and D16-T alloys were found to depend on the composition and character of the corrosive medium. Least corrosion losses were encountered in the metallurgical factory environment for the D16-T alloys with a protective plating of aluminum. Unplated D16-T alloy had the next best corrosion resistance followed by AMts-M and AMg6. Corrosion in aluminum alloy building structures should be determined by losses in strength and depth of corrosion penetration rather than by weight losses. The advantage of aluminum alloys in corrosion resistance over steel in metallurgical factories is greater in open air conditions than inside buildings. Aluminum alloy structures gave long lasting corrosion protection in the range of corrosive media encountered in metallurgical factories. R.N.A.

**N66-12831#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**AN ADDITIVE FOR SUPPRESSING VANADIUM CORROSION OF FUELS**

R. A. Lipshteyn, A. S. Avetisyan et al. 20 Sep. 1965 6 p Transl. into ENGLISH from Soviet Patent no. 162269 (Appl. no. 849707/23-4, 29 Jul. 1963 1 p (FTD-TT-65-505/1+4; AD-621778)

The object of the invention is an additive for suppressing vanadium corrosion of fuels on the basis of green oil. For the purpose of improving the additive's properties tetraethoxysilane or the bottoms in the production of tetraethoxysilane is added to the green oil. Author (TAB)

**N66-12932#** Battelle-Northwest, Richland, Wash.

**CORROSION EVALUATION OF HIGH-SILICON ALUMINUM ALLOYS**

H. C. Bowen Sep. 1965 23 p ref  
(Contract AT(45-1)-1830)  
(BNWL-125) CFSTI: \$1.00

A battery of tests was performed on four high-silicon aluminum alloys containing nickel and/or magnesium. The tests included high and low flow isothermal and nonisothermal 140° C water tests, galvanic couples, stress corrosion cracking tests, and tests in 400° C steam and 360° C water. The HDA-1 and -4 alloys were decidedly superior to the other two alloys in the nonisothermal high flow, the 360° C water, and the 400° C steam tests which are considered the tests of most significance. The HDA-4 alloy had better resistance in high temperature water and is considered the most promising alloy. Author

**N66-12966#** Ilikon Corp., Natick, Mass.

**TECHNIQUES FOR TESTING MATERIALS IN ULTRAHIGH VACUUM**

Paul R. Gould [1964] 16 p refs Presented at Fall Meeting of the Am. Phys. Soc., New England Section, Amherst, Mass., 17 Oct. 1964 (APS64G)

A 20 cubic foot volume ultrahigh vacuum system with an equilibrium pressure of about  $1 \times 10^{-11}$  torr was used for testing materials in this environment. High temperature tensile tests, alloy powder heat treatment, friction studies on dry lubricants, and weight loss measurements were performed. Some details of the experimental techniques are given, and a discussion of methods is presented. Author

**N66-13015\*#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**POTASSIUM CORROSION TEST LOOP DEVELOPMENT: PURIFICATION AND ANALYSIS OF HELIUM FOR THE WELDING CHAMBER Topical Report No. 1**

T. F. Lyon 1 Jul. 1965 48 p refs

(Contract NAS3-2547)

(NASA-CR-54168) CFSTI: HC \$2.00/MF \$0.50 CSCL 14B

A helium analysis system was assembled and used to measure the concentrations of impurities in a vacuum purged, inert gas welding chamber. The analytical system consists of a mass spectrometer and an electrolytic hygrometer to monitor the chamber gas, and a trace oxygen analyzer and electrolytic hygrometer to detect impurities in the inlet helium. It was found that reliable analyses for water vapor could not be obtained with the initial operation of the mass spectrometer. Since water vapor was expected to be one of the chief contaminants within the welding chamber, the electrolytic hygrometer system was installed on the welding chamber and used for the water analyses. The results indicated that the impurities in the welding chamber (other than water vapor) were oxygen, nitrogen, and hydrogen. The mass spectrometer was then calibrated for these three gases, and the reliable detection limit for each of these was estimated to be between one and two volume ppm. Qualitative analyses of other impurities were also obtained. The layout and operation of the mass spectrometer and other analytical instruments used are described, and typical impurity levels encountered in the welding chamber and changes in the impurity levels are given. R.R.D.

**N66-13147#** Pratt and Whitney Aircraft, Middletown, Conn. Canel Div.

**OVERHUNG ROTOR DYNAMICS TESTS USING HYDROSTATIC WATER BEARINGS**

D. A. Newey 24 Jun. 1965 51 p refs  
(Contract AT(30-1)-2789)  
(TIM-874)

This report describes the results of a rotor dynamics test with an overhung mass system using water as a lubricant, which is part of a liquid metal pump development program. Most of the work was directed toward finding a means of predicting and optimizing the conditions required to maintain stable rotation of the shaft. Bearing stiffness was evaluated by use of a hydraulic loading device. The relation between bearing stiffness and stability was studied by observing shaft whirl patterns. Low clearances were found to produce low whirl ratios and considerable hydrodynamic action at high speeds. Higher whirl ratios up to six were obtained by increasing the bearing clearance. The dynamic assembly consisted of a relatively stiff shaft supported by orifice compensated hydrostatic bearings. The amplitude of the synchronous whirl pattern at the system critical speed was found to be negligible due to high fluid damping characteristics. Author

**N66-13178#** Atomic Weapons Research Establishment, Aldermaston (England).

**THE WATER VAPOUR CORROSION OF URANIUM AND ITS PREVENTION**

V. J. Corcoran, C. Johnston, W. J. Metcalfe, and J. Thrope Jul. 1965 20 p refs

(AWRE-O-42/65) CFSTI: HC \$1.00/MF \$0.50



The reaction between uranium and atmospheres containing water vapor in the presence of nitrogen and oxygen has been studied at 25 and 40° C. The steady production of hydrogen from uranium and moist nitrogen was suppressed by the presence of gaseous oxygen, which itself was slowly consumed. The ability of sulphide and arsenic coatings to suppress hydrogen production from uranium in moist nitrogen was also investigated. Author

**N66-13189#** Sandia Corp., Albuquerque, N. Mex.  
**ION PLATED COATINGS FOR THE CORROSION PROTECTION OF URANIUM**  
 R. D. Bland, J. E. McDonald, and D. M. Mattox Oct. 1965 24 p refs  
 (SC-DR-65-519) CFSTI: \$2.00

The feasibility of using the ion plating process to cast depleted uranium with relatively thin aluminum coatings was demonstrated. It was found that electropolishing is preferable to nitric acid dip for surface preparation prior to deposition of the coating, and that the uranium must be kept cool during the ion plating process to prevent surface oxidation. Ion bombardment followed by ion plating provided corrosion protection up to 96 hours exposure in a condensing water vapor atmosphere at 95° C. Various surface preparation techniques and deposition parameters are compared, and results indicate that standard vacuum deposition techniques do not provide adequate protection for uranium. Failure mode analysis shows that the vacuum evaporated coatings fail as a result of vapor penetration through pinholes in the film with subsequent interfacial corrosion and catastrophic adhesive failure. In the ion plated coatings, corrosion was confined to relatively small areas around the original pinholes even after extended exposure. M.G.J

**N66-13268\*** National Aeronautics and Space Administration, Washington, D. C.  
**THE DETERIORATION OF CONTACTS DURING THE SWITCHING OF LOW VOLTAGE (UP TO 220 V) dc AND ac CURRENTS**  
 V. T. Nezhdanov and B. A. Vasil'yev. *In its Elec. Contacts* Dec. 1965 p 169-177 ref (See N66-13251 03-09) CFSTI: HC \$7.45/MF \$2.25

Investigations were conducted to determine the variation in the electric wear of contacts as a function of contact material and the value of the magnetic field in the arc quenching zone when dc current is switched off, and also as a function of contact separation speed when ac current is turned off. Results are discussed. R.N.A.

**N66-13269\*** National Aeronautics and Space Administration, Washington, D. C.  
**RESISTANCE OF CONTACT MATERIALS TO ELECTRIC WEAR**

O. F. Gayday. *In its Elec. Contacts* Dec. 1965 p 178-184 refs (See N66-13251 03-09) CFSTI: HC \$7.45/MF \$2.25  
 Electric contacts of silver, SOM cermet (Ag with 5 to 25% CuO), and SOK15 cermet (Ag with 15% CdO) were evaluated for their resistance to electric wear. The evaluation of the contact materials tested in dc contactors showed that the best contacts were those made of silver and of SOM10 and SOK15 cermets. The least wear by weight was exhibited by silver contacts. The wear by weight of the SOM10 and SOK15 cermet contacts was 1.6 to 1.7 times greater than for silver. A transfer of metal from the anode to the cathode occurred with all the tested contacts. This was most pronounced in silver where the depth of depression on the contact reached 2 mm, but less in SOK15 and even less in SOM10. As a result the SOM10 and SOK15 materials were selected for KM-2000 contactors operating with nominal dc currents up to 300 A. The analysis of contact materials tested in ac contactors shows that the maxi-

mum number of operations was sustained by contacts made from cermets SOM15, SOK15, and SOM10. As a result these three cermets were selected for use in KM-2000 contactors operating with ac currents up to 150 A. R.N.A.

**N66-13388#** Joint Publications Research Service, Washington, D. C.  
**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY NO. 247**  
 26 Nov. 1965 77 p refs Transl. into ENGLISH from Chinese periodicals  
 (JPRS-33046; TT-65-33623) CFSTI: \$3.00

#### CONTENTS:

1. EXPERIMENTAL DETERMINATION OF INERTIA PARAMETERS OF MOVING BODY UNDER WATER K.-h. Chao and Y. Chiang p 1-47 refs (See N66-13389 04-12)
2. STUDIES ON ATMOSPHERIC CIRCULATION IN THE STRATOSPHERE AND THE EFFECT OF SOLAR ACTIVITY ON ATMOSPHERIC CIRCULATION p 48-53 (See N66-13390 04-13)
3. MEANS OF IMPROVING CORROSIVE RESISTANCE OF ALLOYS C.-m. Ch'en p 54-75 refs (See N66-13391 04-17)

**N66-13391** Joint Publications Research Service, Washington, D. C.  
**MEANS OF IMPROVING CORROSIVE RESISTANCE OF ALLOYS**  
 Chun-ming Ch'en. *In its Transl. on Communist China's Sci. and Technol.* No. 247 26 Nov. 1965 p 54-75 refs Transl. into ENGLISH from K'o Hsueh T'ung-pao (Scientia), (Peiping), no. 9, 20 Sep. 1965 p 799-804 (See N66-13388 04-34) CFSTI: \$3.00

The corrosion resistance of alloys is discussed and methods for improving corrosion resistance of alloys are summarized. It is concluded that since the corrosion process of a metal is determined by many complicated factors it is not possible to predict the corrosive properties on the basis of the alloy composition. However, if the principles discussed are followed, the time required to trial produce corrosion resistant alloys will be greatly reduced. E.E.B.

**N66-13426#** Esso Research and Engineering Co., Linden, N. J. Products Research Div.  
**LUBRICITY PROPERTIES OF HIGH-TEMPERATURE JET FUELS** *Quarterly Progress Report*, 15 May-15 Aug. 1965 J. K. Appeldoorn, R. J. Campion, W. G. Dukek, M. J. Furey, and F. F. Tao [1965] 45 p refs  
 (Contract AF 33(615)-2828)  
 (QPR-1; AD-472148)

This is the first quarterly report of work to study the lubricity properties of jet fuels. A field survey of engine and pump manufacturers indicates there is a potential problem when pumping jet fuels, particularly at high pressures, high temperatures and when using highly-purified fuels. Problems in the field include wear, scuffing, sticking, seizure, and fatigue pitting. Laboratory tests on pure hydrocarbons in the jet-fuel boiling range indicate that viscosity is beneficial in reducing wear and friction, but that chemical structure also has some effect. The addition of typical sulfur and nitrogen compounds, surprisingly, gave no reduction in wear and friction. In a vane pump test, a high-purity kerosene gave very excessive wear; adding 1% of a special lubricity additive essentially eliminated the wear. Author (TAB)

**N66-13716#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**CHEMISTRY AND TECHNOLOGY OF FUELS AND LUBRICANTS** *Selected Articles*

15 Sep. 1965 22 p refs Transl. into ENGLISH from Khim. i Tekhnol. Toplivo i Masel (Moscow), no. 8, 19 (FTD-TT-65-704/1+2; AD-621797) CFSTI: HC \$1.00/MF \$0.50

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**N66-13717** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

## ACTION OF ADDITIVES ON WEAR-RESISTANCE ANTI-FRICTION PROPERTIES OF POLYSILOXANE

M. I. Nosov and G. V. Vinogradov *In its Chem. and Tech. of Fuels and Lubricants* 15 Sep. 1965 p 1-9 refs (See N66-13716 04-06) CFSTI: HC \$1.00/MF \$0.50

Experiments were performed to determine the specific action of additives during boundary friction. Polyethylsiloxane fluid (PES) and two polymethylphenylsiloxane fluids with low (polymer 3) and high (polymer 2) content of phenyl groups were used; their properties are tabulated. The relationship between additive activity and the nature of polysiloxane, and the action of molecular oxygen on additive properties were also considered. Results indicate: (1) Additives distinguished by high activity in relation to preventing jamming of steel in hydrocarbon lubricants act very weakly in polysiloxane. (2) Polymethylphenylsiloxane is more sensitive to wear-resistant and anticorrosive additive action. The additives affect the character of mechanical relaxation variations, average value of kinetic friction, and residual friction when the moving surfaces are stopped. (3) Tests in open air and under a vacuum of sulpho-, chlorine-, and phosphor-organic compounds in polyethylsiloxane show that molecular oxygen affects additive efficiency. M.G.J.

**N66-13718** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**DETERMINATION OF ANTIOXIDANT ADDITIVES IN OILS BY THE THIN-LAYER CHROMATOGRAPHIC METHODS** N. D. Zubkova, Yu. I. Turskii, V. I. Genkina, and G. V. Klyuchko *In its Chem. and Tech. of Fuels and Lubricants* 15 Sep. 1965 p 11-19 refs (See N66-13716 04-06) CFSTI: HC \$1.00/MF \$0.50

For qualitative analysis of additives in lubricating oils, the possibility of using thin-film chromatography on a nonfixed layer of aluminum oxide was examined. Details are given on the chromatographic analysis of alkyl-phenols and aryl-amines, and the application of this method for identifying antioxidant additives in oils is described. Mineral oil, and synthetic oil on a dioctyl-sembacinate base were investigated, and results indicate that amine compounds are present in the synthetic oil. The data were experimentally confirmed by separating the detected antioxidant additives from the analyzed oils, recrystallizing them from the solvents for purification, and identifying them. It was concluded that the method has the advantages of simplicity, high sensitivity, and speed (about 15 to 20 minutes); and permits detection of an antioxidant additive in oil at a minimum concentration of 0.05%. M.G.J.

**N66-13754#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**METHOD OF STABILIZING SILICONE OILS**

G. S. Tubyanskaya and R. I. Kobzova 21 Sep. 1965 5 p Transl. into ENGLISH from Soviet Patent No. 162268 (Appl. No. 856107/23-4. 9 Sep. 1963) 1 p (FTD-TT-65-520/1+4; AD-622349) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is a method of stabilization of silicone oils by means of the introduction of additives which has the distinguishing feature that, as an additive, cyclopentadienyl tricarbonyl manganese is introduced. Author (TAB)

**N66-13775#** MSA Research Corp., Callery, Pa  
**FACTORS AFFECTING THE COMPATIBILITY OF LIQUID CESIUM WITH CONTAINMENT METALS** Second Quarterly Progress Report, May-Jul. 1965

F. Tepper and J. Greer 26 Aug. 1965 13 p (Contract AF 33(615)-2386) (MSAR-65-111)

The mechanisms of attack of structural metals by cesium metal is being studied. A two phase natural convection loop has been fabricated. The ultrahigh vacuum test chamber to be used in operation of refractory metal loops has been received, modified and checked out. Mass transfer tests have been performed with iron and nickel. The mass transfer rate is being measured gravimetrically. Author

**N66-13857#** Pratt and Whitney Aircraft, Middletown, Conn. Advanced Nuclear Engineering Lab

## APPLICATION OF INTERNAL FRICTION METHODS TO CORROSION STUDY IN COLUMBIUM ALLOYS

G. F. Schenck 30 Jul. 1965 21 p refs Presented at the ASM Symp. on Anal. Uses of Internal Friction at the ASTM Ann. Meeting, Purdue Univ., Lafayette, Ind., 16 Jun. 1965 (Contract AT(30-1)-2789) (CNLM-6344)

Lithium corrodes niobium and niobium-zirconium alloys intergranularly and on the <110> crystallographic planes when these alloys are contaminated with oxygen. In certain heat treated conditions, however, niobium-zirconium alloys are not attacked by the alkali metal even though they contain relatively large concentrations of oxygen. The internal friction behavior of oxygenated Nb-1 Zr alloy was studied to determine the physical situation of oxygen in the alloy at various heat treatment conditions. From this investigation it became apparent that lithium is only able to corrode the niobium metal or alloy if the oxygen is in interstitial solid solution. Heat treatment of the Nb-1 Zr alloy at temperatures near 2200° F permits corrosion stabilization of the alloy with oxygen concentrations as great as 2.1 atom fraction of the zirconium. The corrosion stabilization is achieved by precipitation of the oxygen as zirconium dioxide. Author (NSA)

**N66-13944#** Laboratoires du Centre d'Etude de l'Energie Nucleaire, Mol (Belgium).

## IMPERFECTIONS IN METALS. II: CORROSION AND OXIDATION

Quarterly Report No. 8, 1 Jul.-31 Sep. 1964 [1964] 32 p refs (Contract EURATOM-082-62-7 RDB) (EUR-2363; EURAEC-1404; R-2316) CFSTI: HC \$2.00/MF \$0.50

Thermal oxidation films formed on annealed titanium foils were recrystallized in order to study the defect structure of the rutile modification of titanium dioxide. By this procedure large monocrystalline areas were obtained suitable for transmission electron microscopy and diffraction. Several contrast effects were observed in these films. Extended fringe patterns, which sometimes formed closed loops, are attributed to antiphase boundaries. A model for the occurrence of this type of defect based on the idealized image of a hexagonal close-packed stacking of the oxygen ions in the rutile structure is proposed.

\* This model is also reliable with the observation of twins with the (101) plane as boundary plane. The habit plane of the antiphase boundaries is in an irrational plane for the tetragonal rutile lattice; it is however a simple plane in the oxygen lattice. The antiphase boundaries moved easily under enhanced electron irradiation. Mutual annihilation and disappearance of the boundaries was observed by annealing in the microscope. The model further explains the observation of antiphase boundaries ending at dislocations and the behavior at the contract between these boundaries and twin boundaries. Finally, geometrically shaped contrast features were observed which are attributed to cavities. Author

**N66-13991\*** Tyco Labs., Inc., Waltham, Mass.  
**DEVELOPMENT OF CATHODIC ELECTROCATALYSTS FOR USE IN LOW TEMPERATURE H<sub>2</sub>/O<sub>2</sub> FUEL CELLS WITH AN ALKALINE ELECTROLYTE** First Quarterly Report, Jul. 1-Sep. 30, 1965

A. C. Makrides, R. J. Jasinski, and J. Giner [1965] 59 p (Contract NASw-1233)

(NASA-CR-68891) CFSTI: HC \$3.00/MF \$0.50 CSCL 07D

Various metallic ingots were prepared and tested for corrosion resistance and electrocatalytic activity in a rotating electrochemical cell, the temperature of which can be regulated. The solid ingots were mounted in an alkali resistant resin and tested potentiostatically as a rotating disc electrode run consecutively in N<sub>2</sub>- and O<sub>2</sub>-saturated KOH solution. The method of preparing the solid ingots as rotating disc electrodes is described, and schematic diagrams of a rotating disc electrode, a rotating electrode cell, and a floating electrode cell are shown. Current potential curves for Pt, Au, Ag, Ta, Zr<sub>2</sub>Ni, TiNi, NbPt, TiCu, TaPt<sub>2</sub>, TiPt<sub>3</sub>, TaPt<sub>3</sub>, TiCu<sub>3</sub>, ZrAu<sub>3</sub>, NbNi<sub>3</sub>, TiNi<sub>3</sub>, TiCr<sub>4</sub>, WC, Cr<sub>3</sub>C<sub>2</sub>, TiC, and Ni<sub>3</sub>B are given. L.S.

**N66-14061\*** Pratt and Whitney Aircraft, East Hartford, Conn.  
**BRAYTON-CYCLE TURBOMACHINERY ROLLING-ELEMENT BEARING SYSTEM** First Quarterly Report, Jul. 2-Oct. 2, 1965

H. Means Oct. 1963 74 p refs

(Contract NAS3-7635)

(NASA-CR-54785; PWA-2713) CFSTI: HC \$3.00/MF \$0.75 CSCL 13I

The potential of oil lubricated rolling element bearings for the Brayton-cycle space power machinery was investigated. A basic bearing-seal lubrication, scavenge, and separation system concept adaptable to the machinery developed was evolved. Mechanical design work was initiated on the turbine compressor and the turboalternator to replace the gas bearing rotor support system with an oil lubricated rolling element bearing system. A detailed design analysis was made to define the geometry of the rolling element bearings for the turbine compressor. Lubricant evaluations were initiated to form a basis for selection of the optimum lubricant for the Brayton-cycle turbomachinery. The effects of oil contamination of the working fluid (argon) were studied to establish limiting oil contamination criteria. R.W.H.

**N66-14066\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.  
**DISTRIBUTION OF FAILURE TIMES IN STRESS CORROSION TESTS**

J. B. Gayle 1 Nov. 1965 16 p refs

(NASA-TM-X-53355) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

The results of stress corrosion tests on aluminum alloys have been analyzed with respect to the statistical nature of the distribution of failure times. The analyses indicated that the data were represented adequately by a three-parameter Weibull distribution in which the induction period amounted to 85 percent of the time of the first observed failure and 55 percent of the time required for failure of half the specimens. Author

**N66-14170#** Atomic Weapons Research Establishment, Aldermaston (England).

**THE CORROSION AND IGNITION BEHAVIOUR OF SOME URANIUM/PLUTONIUM/IRON ALLOYS. PART 2: ALLOYS CONTAINING MORE THAN 8 a/o IRON**

G. Picton and J. F. Sackman May 1965 16 p refs

(AWRE-O-18/65) HMSO: 3s 3d

Alloys containing 16.2 and 16.8 a/o iron have been compared with an alloy containing 7.7 a/o iron. There was no improvement in either the corrosion or the ignition behavior. Under accelerated corrosion conditions the 16.2 a/o iron alloy can corrode more rapidly at ~0% r.h. than at 95% r.h. because of cracking and disintegration. It is concluded that casting conditions are the most important parameters for good corrosion and ignition behavior. Author

**N66-14228#** Southwest Research Inst., San Antonio, Tex.  
**LUBRICATION RESEARCH AND TEST METHOD DEVELOPMENT FOR AEROSPACE PROPULSION SYSTEMS** Technical Report, 15 Feb. 1964-15 Apr. 1965

B. B. Baber, W. R. Blackstone, and P. M. Ku Wright-Patterson AFB, Ohio, AF Aero Propulsion Lab., Aug. 1965 68 p refs

(Contract AF33(657)-11088)

(AFAPL-TR-65-70; AD-621072) CFSTI: HC \$3.00/MF \$0.75

This program was concerned with the further development of the ABMA impact tester and the investigation of different test methods used to determine the impact sensitivity of materials in contact with rocket propellants. It was found that the specimen cup material and design had a significant effect on plummet rebound height. The use of a modified anvil region assembly, including a steel specimen cup, significantly increased the reactivity of materials subjected to impact in the presence of LOX in addition to improving plummet rebound height repeatability. The 'up-and-down' test procedure, from which a statistical estimate of the drop height producing a 50-percent probability of reaction may be obtained was investigated. The results of 10 separate up-and-down tests on one grease material showed repeatability to be excellent. Results were also obtained for additional greases and these results showed that some greases rated as satisfactory had about the same 50-percent points as other greases considered unsatisfactory with the only apparent difference being the intensity of the reactions. Author (TAB)

**N66-14232#** Naval Research Lab., Washington, D. C. Metallurgy Div.

**MARINE CORROSION STUDIES: STRESS-CORROSION CRACKING, DEEP OCEAN TECHNOLOGY, CATHODIC PROTECTION, AND CORROSION FATIGUE** Third Interim Report of Progress

B. F. Brown, B. W. Forgeson, T. J. Lennox, Jr., T. C. Lupton, R. L. Newbegin et al Jul. 1965 97 p refs

(NRL-Memo-1634; AD-621743) CFSTI: HC \$3.00/MF \$0.75

Contents: stress-corrosion cracking of titanium alloys in salt water, fresh water, and sea water; stress-corrosion cracking tests on welded titanium alloy plates; a new stress-corrosion cracking test procedure for high strength alloys; a study of the stress factor in corrosion cracking by use of the pre-cracked cantilever beam specimen; a study of the crystallographic orientation of cleavage facets produced by stress-corrosion cracking of Ti-7Al-2Zr-1Ta in distilled water; the effectiveness of sodium chromate to inhibit stress-corrosion crack propagation in aisi 4340 steel; metallic corrosion and cathodic protection to 5652 foot ocean depths; performance of tributyl tin oxide and cuprous oxide antifouling paints on 5086-H32 and 6061-T6 aluminum alloys in sea water and river water exposures; status report on the current distribution along a wire rope cathode; inoperative galvanic anodes related to improper chemical composition of the zinc; determination of the effective driving potential and effective d.c. resistance of galvanic anodes; low cycle fatigue crack propagation in 'wet environments'. TAB

**N66-14309#** Army Weapons Command, Rock Island, Ill. Research and Engineering Div.

**TRANSPARENT FLEXIBLE HEAT SEALABLE FILMS—EVALUATION OF ABILITY TO PROTECT AGAINST CORROSION**

Richard Murrens Jun. 1965 18 p  
(RIA-65-1588; AD-623300) CFSTI: HC \$1.00/MF \$0.50

Ten different transparent plastic films were evaluated for their ability to provide protection against corrosion to steel panels with and without preservation in an accelerated humidity environment. The films represented water vapor transmission rate (WVTR) values currently required by military specifications. Results showed that films with low WVTR values did not prevent the entrance of water vapor, which resulted in corrosion. Prevention against corrosion was maintained for extended periods of time only when preservatives were used.

Author (TAB)

**N66-14463#** SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**A BASIC STUDY OF THE SLIDING CONTACTS IN ROLLING BEARINGS, PROJECT II Progress Report No. 2, Jul. 17–Oct. 16, 1965**

C. J. Belsky, W. E. Schmidt, J. A. Kamenshine, K. Tataiah, and J. I. McCool [1965] 122 p refs  
(Contract N0w-65-0182-f)

(AL65L081; AD-623665) CFSTI: HC \$4.00/MF \$0.75

A 2-ball test machine, especially designed for sliding tests and capable of being used with irradiated balls for purposes of wear determination, was used to determine the load-speed relationship at the initiation of smearing failure in a sliding 2-ball configuration for three highly refined mineral oils and three ester-type lubricants. A configuration of three crowned cylindrical rollers was operated between two flat thrust washers in the presence of a non-metallic cage. The elastohydrodynamic film condition between rollers and flat washers was determined using a previously developed contact conductivity method. Preliminary surface microgeometry trackings were made on the test elements and the required modification of statistical theories relating conductivity results to the film thickness/roughness ratio was accomplished. Kinematical studies were made of the axial roller motion and skew of cylindrical rollers running in a conventional cylindrical roller bearing with flanged outer ring, in aligned or misaligned conditions.

TAB

**N66-14468#** Naval Air Engineering Center, Philadelphia, Pa. FOUNDATIONAL RESEARCH PROGRAM

1965 219 p refs  
(AD-623630) CFSTI: HC \$5.00/MF \$1.25

Progress is reported on twenty-six research projects. These include the following: *Fluid Mechanics; Lubrication of Metal Surfaces with Solid Films; Oxygen Embrittlement of Metals; Aircraft Ejection Seat Design; Salt Water Permeation through Organic Protective Coatings; High Strength Aluminum Alloy Corrosion; Biological Stress; Maser Spectroscopy; Air Bubble Test Vehicle; Jet Noise Suppression; Polarization Studies of Corrosion; Polymer Chemistry; Electron Microfractography; Metabolic Mechanisms of Man; Deep-Sea Simulation; Turbines; Radiation; Thermoplastics; Neutron Activation Analysis; Synthetic Fibers; Heat Transfer; Catapult Operations; Missile Launching; and Hydrogen Embrittlement of Metals and Alloys.*

E.E.B.

**N66-14469#** Southwest Research Inst., San Antonio, Tex. FUNDAMENTAL INVESTIGATION OF MOLYBDENUM DISULFIDE AS A SOLID LUBRICANT Final Technical Report, Jul. 23, 1964–Jul. 22, 1965

J. C. Tyler and P. M. Ku 23 Aug. 1965 70 p refs  
(Contract N0w-64-0545-f)  
(RS-460; AD-623484) CFSTI: HC \$3.00/MF \$0.75

A basic test facility for performing compression, tension, torsion, cohesion, adhesion, and sliding experiments on cylindrically shaped molybdenum disulfide ( $\text{MoS}_2$ ) specimens in a controlled atmosphere or in vacuum was designed, fabricated, and put into operation. Compacts of a reference  $\text{MoS}_2$  powder and a commercially available  $\text{MoS}_2$  powder were made, without the use of a binder, over a wide range of compacting pressures and length-to-diameter ratios. Data were obtained on the variations of compact specific gravity and hardness with respect to compacting pressure and length-to-diameter ratio. Measurements were also made on the compressive and tensile properties of the  $\text{MoS}_2$  specimens in clean dry air and at room temperature. The ultimate compressive and tensile strength were determined over a wide range of specimen specific gravities, as were the moduli of elasticity in compression and tension.

Author (TAB)

**N66-14567#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THERMAL STABILITY OF ANTIWEAR ADDITIVES IN LUBRICATING OILS**

A. M. Ravikovich, Ye. I. Petyakina, and P. P. Bagryantseva 17 Sep. 1965 10 p refs Transl. into ENGLISH from Khim i Tekhnol. Topliv i Masel (Moscow), no. 12, 1964 p 44–47

(FTD-TT-65-867/1+4; AD-622474) CFSTI: HC \$1.00/MF \$0.50

Use of a four-sphere friction machine to evaluate anti-scratching and antiwear properties of oils is discussed, and the test methods are described. Results indicate that anti-scratching admixtures containing sulfur, chlorine, and lead do not improve the antiwear properties of mineral oils while admixtures containing phosphorus exhibit an antiwear effect. A method developed to determine thermal stability (TS) of antiwear admixtures is also described. It is applicable for working concentrations of admixtures in lubricating oils, and permits the evaluation of the wear resistant effect of the admixture and oil soluble products of its decomposition. The admixture solution in oil is poured into a hermetically capped small stainless steel receptacle, which is heated in an aluminum bath arrangement at a given temperature for a specified length of time, cooled, filtered, and tested on a four-ball friction machine. Formulas are given for the admixtures tested, the decomposition temperatures of each are tabulated, and the TS values are listed. It was shown that the decomposition point of dialkyl-dithiophosphate additives depends to a considerable degree upon the nature of the oil and the presence of other additives.

M.G.J

**N66-14754\*#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**STUDIES OF ALKALI METAL CORROSION ON MATERIALS FOR ADVANCED SPACE POWER SYSTEMS Quarterly Progress Report No. 5, Jun. 26–Sep. 26, 1965**

R. W. Harrison [1965] 25 p refs

(Contract NAS3-6012)

(NASA-CR-54844) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

Two stress corrosion reflux capsule tests are reported for a niobium-base alloy, designated D-43, in potassium. The first test completed 1000 hours at 2100° F; was removed from the test facility; and drained of potassium, cleaned, and sectioned. Although there were spots in the liquid and condensing regions on the inner surface of the capsule, these locations were not associated with regions of high stress. Lower uniaxial creep strengths were obtained from capsule test data than were predicted by pretest and literature data. Equivalent uniaxial creep strains of 7.4% in the liquid region and 5.4% in the condensing region were calculated. The second reflux capsule test has logged 1600 hours at 2050° F, and is still in progress. M.W.R.

**N66-14785\*** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.  
**POTASSIUM CORROSION TEST LOOP DEVELOPMENT**  
 Quarterly Progress Report No. 8, 15 Apr.-15 Jul. 1965  
 E. E. Hoffman, ed. 23 Nov. 1965 50 p refs  
 (Contract NAS3-2547)  
 (NASA-CR-54843) CFSTI: HC \$3.00/MF \$0.50 CSCL 11F

Development of a prototype corrosion test loop for the evaluation of refractory alloys in boiling and condensing potassium environments which simulate projected space electric power systems is reported. The prototype test consists of a two-loop Cb-1Zr facility; sodium will be heated by direct resistance in the primary loop and will be used in a heat exchanger to boil potassium in the secondary, corrosion test loop. Heat rejection for condensation in the secondary loop will be accomplished by radiation in a high-vacuum environment to the water cooled vacuum chamber. Purification of the alkali metals for the prototype loop was performed. Checkout tests of the prototype loop equipment and controls were conducted and calibration of system instrumentation was completed prior to increasing system temperatures and flows to the design conditions. The results of the 5000-hour, 2000° F refluxing potassium capsule test to determine the compatibility of Mo-TZM alloy in a Cb-1Zr container indicate that no significant corrosion problem exists in this system at temperatures equivalent to those planned for the prototype loop test. M.R.W.

**N66-15016\*** Naval Research Lab., Washington, D. C.  
**NMR ANALYSIS OF MIXED PENTAERYTHRITOL, DIPENTAERYTHRITOL, AND 1,1,1-TRIMETHYLOLPROPANE ESTERS**

W. B. Moniz and C. F. Poranski, Jr. 19 Aug. 1965 25 p refs (NRL-6307; AD-621566) CFSTI: HC \$1.00/MF \$0.50

Benzene solutions of mixed pentaerythritol, dipentaerythritol, and 1,1,1-trimethylolpropane esters may be quantitatively assayed by proton NMR spectroscopy with an absolute accuracy of  $\pm 5$  mole-% for each of the ester types. Higher accuracies are possible if a calibration curve is used. Average acid chain length and the approximate degree of chain branching are also obtained. The NMR method can be used for monitoring base stocks, checking blend compositions, and determining constancy of formulation of oils qualified under specification MIL-L23699. NMR analyses of a group of commercial esters and of several aircraft engine lubricant formulations were made. Results were obtained on both the Varian A-60 and HA-100 spectrometers, with comparable accuracy. The A-60 is felt to be the preferred instrument, however, because its integrals are simpler to process. Author (TAB)

**N66-15087\*** Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires.  
**ATMOSPHERIC CORROSION OF URANIUM-CARBON ALLOYS [CORROSION ATMOSPHERIQUE DES ALLIAGES URANIUM-CARBONE]**

Pierre Rousset and Andre Accary May 1965 47 p refs In FRENCH  
 (CEA-R-2732) CFSTI: HC \$2.00/MF \$0.50

The corrosion of uranium-carbon alloys having compositions close to that of the mono-carbide was studied. It is shown that the extent of the observed corrosion effects increases with the water vapor content of the surrounding gas, and it was concluded that the atmospheric corrosion of these alloys is due essentially to the humidity of the air, the effect of the oxygen being very slight at room temperature. Optimum conditions for preserving U-C alloys are either a vacuum or a perfectly dry argon atmosphere. The type of corrosion involved is one that cracks under stress and is transgranular (it can also be intergranular in the case of substoichiometric alloys). Two hypotheses for explaining this mechanism are proposed, one of which is

illustrated by the existence, at the fissure interface, of corrosion products which can play the role of corners in the monocarbide grains. Author (NSA)

**N66-15092\*** Union Carbide Nuclear Co., Oak Ridge, Tenn. Y-12 Plant.

**PRODUCTION-SIZE LATHE HYDROSTATIC COMPONENTS**  
 P. J. Steger 21 May 1965 15 p Presented at the ASME Spring Lubrication Symp., New York, 7-9 Jun. 1965  
 (Contract W-7405-ENG-26)

(Y-DA-921; Conf-650651-1) CFSTI: HC \$1.00/MF \$0.50

Two lathe components using hydrostatic air bearings are described: a hydrostatic boring bar and a production-size spindle. Porous graphite bearing pads are used in both components. The accuracy and performance of the components are discussed. NSA

**N66-15186\*** Aerojet-General Corp., Azusa, Calif.  
**SNAP-8 MATERIALS REPORT FOR JULY-DECEMBER 1964**

H. Derow and B. E. Farwell Jan. 1965 111 p refs /its Rept.-2989

(Contract NAS5-417)

(NASA-CR-54718) CFSTI: HC \$4.00/MF \$0.75 CSCL 18N

Progress is reported on the project to provide data to guide the selection of materials for SNAP-8 system components and of providing metallurgical assistance in the design, development, fabrication, and testing of that system. Among the work completed was the fabrication and testing of a prototype condenser tube-to-tube sheet joint sample representing the 0.5-inch-diameter tube end. Also, analytical methods were established for evaluating the lubricant-coolant fluid. These methods included gas chromatographic determination of isomer ratios and volatile impurities, halogen analysis, and phenol analysis. Creep rupture tests were conducted on welded and unwelded 9%Cr-1%Mo steel specimens to evaluate the gross creep rupture strength efficiency of welds. The tests were run at 1325° F at two stress levels, 1600 and 2300 psi. The results indicate that welding does not decrease the creep or creep rupture strength of this material at 1325° F. The assembly and installation of the CL-4 was completed during the period. The design and operating parameters of a hydrogen injector system for use in CL-4 were also completed. Flat sheet refractory bimetal tube material specimens were exposed to 1350° and 1450° F in a vacuum for 500, 1000, and 2500 hr to evaluate cross bond diffusion effects. E.E.B.

**N66-15241\*** National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.  
**IN-FLIGHT TEST TO DETERMINE SPACE ENVIRONMENTAL EFFECTS ON FRICTION, WEAR, AND LUBRICATION OF MATERIALS**

Harold E. Evans and Edward J. Devine [1965] 15 p Presented at the AIAA 2d Ann. Meeting and Tech. Display, San Francisco, 26-29 Jul. 1965 Submitted for Publication

(NASA-TM-X-54967) CFSTI: HC \$1.00/MF \$0.50 CSCL 13H

Measurement of rolling and sliding friction and cold welding effects in orbit is the purpose of a proposed experiment designed on a modular basis. The modules, which may be combined as necessary to fit the final space and power available in the spacecraft include: (1) a bearing test module to test eight instrument bearings under load and to measure torque and time to failure; (2) one to three friction and wear test modules to make measurements of six different combinations of materials; and (3) a pressure transducer to measure total pressure in the vicinity of the experiment. Several illustrations of the modules are included. M.W.R.

**N66-15243\*** # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FLUORIDE SOLID LUBRICANTS FOR EXTREME TEMPERATURES AND CORROSIVE ENVIRONMENTS**

Harold E. Sliney, Thomas N. Strom, and Gordon P. Allen. Washington, NASA, 1964 37 p refs Presented at the 20th Ann. Meeting of the Am. Soc. of Lubrication Engrs., Detroit, 4-6 May 1965

(NASA-TM-X-52077) CFSTI: HC \$2.00/MF \$0.50 CSCL 11H

Fluorides of the alkali metals and the alkaline earth metals have an interesting combination of properties that make them promising candidates as solid lubricant materials for use at high temperatures and in corrosive environments. They are chemically inert in strong oxidizing or reducing environments; they are relatively soft and nonabrasive; and some of them, such as  $\text{CaF}_2$ , have planes of perfect cleavage in their crystal structure suggesting low shear strength and good friction properties. Thin, fused fluoride coatings (0.001 in.) were applied to nickel-chromium alloys by spraying water slurries of the fluorides on the bearing surface, drying, then firing in a hydrogen atmosphere. Coatings of  $\text{CaF}_2$ -LiF mixtures and of  $\text{CaF}_2$ - $\text{BaF}_2$  mixtures were effective as solid lubricants in hydrogen to 1500° F and in air to 1200° F.  $\text{CaF}_2$ - $\text{BaF}_2$  coatings were effective solid lubricants in liquid sodium at 1000° F and a sliding velocity of 2000 ft/min. Author

**N66-15366\*** # SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**SUPERSONIC TRANSPORT LUBRICATION SYSTEM INVESTIGATION Second Semiannual Report**

C. G. Hingley and L. B. Sibley 20 Nov. 1965 125 p refs (Contract NAS3-6267)

(NASA-CR-54312; SKF-AL65T077) CFSTI: HC \$4.00/MF \$1.00 CSCL 13I

Ball bearings and bellows face seals for use on Mach 3 aircraft gas turbine engine mainshafts, and suitable test rigs to simulate engine operating conditions, have been manufactured and check-out testing conducted on all hardware and test systems. A development program is underway to determine the most suitable combination of presently available materials and lubricants to permit operation of these bearings and seals under typical engine load and speed conditions at the highest possible ambient temperature above 600° F with the seals exposed to 1200° F air and a pressure differential of 100 psi. Tests are conducted primarily using a nitrogen-blanketed bearing chamber and lubricant system. Test lubricants are being screened for their potential performance under two different application techniques, namely, jet lubrication of the bearings with circulating oil, and once-through lubrication in the form of oil mist. Author

**N66-15373\*** # General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

**ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM Quarterly Progress Report No. 2, 15 Jul-15 Oct. 1965**

R. W. Harrison, ed. [1965] 31 p refs

(Contract NAS3-6474)

(NASA-CR-54845) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

Progress is reported on a program to fabricate, operate for 10000 hours, and evaluate a potassium corrosion test loop constructed of T-111 alloy. The T-111 alloy was selected as the containment alloy and Mo-TZC and Nb-132M alloys were selected for inclusion in the turbine simulator. Revisions in the prototype corrosion loop assembly drawings were made based on experience gained in fabrication, installation, and operation of the loop. Specifications for cleaning, welding, and heat treating loop components are being prepared. R.N.A.

**N66-15491\*** # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FRICTION, WEAR, AND ADHESION CHARACTERISTICS OF TITANIUM-ALUMINUM ALLOYS IN VACUUM**

Donald H. Buckley and Robert L. Johnson. Washington, NASA, Jan. 1966 18 p refs

(NASA-TN-D-3235) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

Friction, wear, and adhesion measurements were made in vacuum ( $10^{-5}$  mm Hg) of titanium-aluminum alloys containing 11.16 and 21 weight percent aluminum. Experiments were conducted with a 3/16-inch-radius rider sliding on the flat surface of a 2-1/2-inch-diameter disk specimen at loads to 1500 grams. The disk was rotated to produce sliding velocities to 750 centimeters per second. With increasing addition of aluminum to titanium, an increase in lattice ratio (c/a) for titanium occurred along with a decrease in friction, wear, and adhesion. The increase in (c/a) lattice ratio with the addition of aluminum to titanium occurred even though the unit cell size decreased; these results are unlike those with the addition of tin and oxygen to titanium. While titanium exhibited an adhesion coefficient of 5.3, the titanium-aluminum alloys exhibited adhesion characteristics which could be considered negligible. These alloys exhibited superior friction and wear properties in vacuum compared with 52100 and 440-C stainless than when sliding on themselves. Author

**N66-15492\*** # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**INFLUENCE OF ORIENTATION OF GRAINS IN TUNGSTEN ON ITS FRICTION CHARACTERISTICS**

Donald H. Buckley. Washington, NASA, Jan. 1966 23 p refs (NASA-TN-D-3238) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

The influence of crystallographic orientation on the friction properties of tungsten was determined in both air and vacuum. Friction measurements were made with a 3/8-inch oriented sapphire ball sliding on a large grained tungsten disk, and the orientation of each grain on the tungsten surface was determined. The two sapphire orientations examined were the (0001) plane, [1010] direction, and the (1010) plane, [0001] direction, sliding on the tungsten surface. The sapphire ball was loaded against the disk with a 500-gram load. The disk was then rotated to produce sliding velocities of 0.013 and 0.001 centimeter per second. The vacuum experiments were conducted with electron-cleaned surfaces at  $10^{-10}$  millimeter of mercury. The investigation indicates that tungsten exhibits anisotropic friction properties. Friction characteristics on different crystal planes in a particular direction did not differ markedly; considerable differences in friction coefficient, however, existed in changing crystallographic directions on particular planes. Further, marked differences in friction were observed with changes in crystallographic orientation of the sapphire. Friction decreased considerably when vacuum measurements were repeated in air. Author

**N66-15554\*** # Sandia Corp., Albuquerque, N. Mex.

**ION PLATING OF SPRF REACTOR PARTS Development Report**

D. M. Mattox and R. D. Bland. Nov. 1965 21 p refs

(SC-DR-65-530) CFSTI: \$1.00

It has been found that SPRF reactor parts are protected from corrosion more effectively by an ion-plated coating of aluminum than by an electroplated nickel coating. Extensive detail is given on the technique of ion plating aluminum on the reactor parts and on observations made during plating. Stripping of the aluminum plating from several of the pieces showed the probable existence of an aluminum-uranium intermetallic, interfacial layer formed during the deposition process. Some possible improvements on the plating process are given based on the experience gained in plating these parts. Author

**N66-15557#** Marine Engineering Lab., Annapolis, Md.  
**STATE-OF-THE-ART SURVEY ON HOT CORROSION IN MARINE GAS-TURBINE ENGINES**  
 G. J. Danek Mar. 1965 36 p refs  
 (MEL-32/65; AD-461181)

This summary describes a state-of-the-art survey of hot corrosion problems which can seriously limit the suitability of gas-turbine engines for marine propulsion systems. Catastrophic attack of nickel- and cobalt-base superalloys at temperatures above 1550° F is attributed to the action of a molten slag that forms by the reaction of ingested sea salt and sulfur contained in the fuel. A general lack of agreement was found to exist among investigators on the mechanisms of sulfidation corrosion, methods of sorting and screening materials, resistance of specific materials to attack, and proposed solutions to the problem. Nevertheless, the collected information provided valuable guidance in formulating the Navy's Marine Gas-Turbine Alloy Development Program. A description of this program and specifications selected for standardized equipment to evaluate sulfidation resistance are presented.

Author (TAB)

**N66-15815\*#** Pratt and Whitney Aircraft, West Palm Beach, Fla. Florida Research and Development Center.  
**RESEARCH AND DEVELOPMENT OF MATERIALS FOR USE AS LUBRICANTS IN A LIQUID HYDROGEN ENVIRONMENT** Final Report, Jul. 1964-Nov. 1965  
 W. H. Rempe and W. E. Young 29 Oct. 1965 69 p  
 (Contract NAS8-11537)  
 (NASA-CR-69569; PWA-FR-1602) CFSTI: HC \$3.00/MF \$0.75 CSCL 13H

The objective of the program was to develop materials for use as lubricants in rolling-element bearings operating in a liquid hydrogen environment at DN levels up to  $4.0 \times 10^6$  mm-rpm. In the first phase, the results of which were previously reported, 10 candidate lubricant materials were selected and evaluated in a ball-plate test apparatus. In the second phase, 10 additional materials were evaluated, and from the 20 candidates, the four most promising were selected for testing in actual 80-mm bearings at speeds up to 50 000 rpm.

Author

**N66-15921#** United Kingdom Atomic Energy Authority, Harwell (England), Chemistry Div.  
**STRESS CORROSION OF IRRADIATED STAINLESS STEELS**

M. J. Davies, D. A. Landsman, and W. E. Seddon Aug. 1965 21 p refs  
 (AERE-R-5014) HMSO: 2s 6d

Fully annealed specimens of Type-316 stainless steel and of a 20 Cr-25 Ni-Nb-stabilized stainless steel were subjected to stress corrosion tests in boiling 42% MgCl<sub>2</sub> solution: identical specimens were exposed to the same test after receiving doses of fast neutrons up to  $2 \times 10^{20}$  n-cm<sup>-2</sup>. Irradiation of the Type-316 steel greatly increased its susceptibility to stress corrosion cracking at low stress levels, but the 20-25-Nb steel was immune to cracking in both irradiated and unirradiated conditions. It is proposed that the effect on the Type-316 steel is due to fast neutron radiation damage in the oxide film on the metal.

Author

**N66-16058\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.  
**EVALUATION OF IMPREGNATED LUBRICANTS IN BALL-BEARING RETAINERS AT  $10^{-6}$  TORR**

L. Dale Smith, Dean C. Glenn, and Herbert W. Scibbe Washington, NASA, Feb. 1966 21 p refs  
 (NASA-TN-D-3259) CFSTI: HC \$1.00/MF \$0.50 CSCL 13I

Four liquid lubricants, a polyphenyl ether, polysiloxane, a sebacate, and a high-viscosity mineral oil, were evaluated as lubricating impregnants in cotton-cloth phenolic retainers of

20-millimeter-bore ball bearings operating in a vacuum of  $10^{-6}$  torr. The effect of the cloth weave on the lubricating effectiveness of the best of the lubricants was also studied. The test bearings were run at 3550 rpm under axial loads of 50 to 100 pounds (22.7 to 45.4 kg) for 1 hour, or until the torque exceeded and remained above 20 inch-ounces (14.1 cm-N). Although none of the lubricants provided good lubrication in the vacuum environment of this system, the most acceptable lubricant was the mineral oil. It provided the lowest torque levels and torque roughness and carried the maximum load for the full duration of the test. High initial torques occurred frequently with all of the lubricants, which indicated inadequate lubrication during the initial part of the run. Comparing bearing performance obtained with only impregnated retainers to that obtained with both impregnated retainers and pre-lubrication showed that the impregnated retainers used did not feed the lubricant fast enough to provide good lubrication at the conditions of this investigation. In additional tests with the high-viscosity mineral oil, varying the weave of cloth in the retainer produced no significant improvements in the bearing torque.

Author

**N66-16158\*#** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.  
**SIMULATION OF THE J-2 ENGINE GIMBAL BEARING**  
 K. E. Demorest and K. W. Wilks 20 Jan. 1966 23 p refs  
 (NASA-TM-X-53379) CFSTI: HC \$1.00/MF \$0.50 CSCL 11H

A test apparatus, designed to simulate the operation of the J-2 engine gimbal system, was used to test the J-2 gimbal lubricant at atmospheric pressure, at  $10^{-6}$  mm of Hg, and over a wide range of temperatures. The currently specified gimbal lubricant, Fabroid consists of woven glass and Teflon fibers bound together with a phenolic resin. The Fabroid lubricant provided a low and constant coefficient of friction both at atmospheric pressure and at  $10^{-6}$  mm of Hg at loads to 25 000 psi as long as the ambient temperature remained constant. However, the coefficient of friction of Fabroid was shown to be temperature dependent, increasing sharply with reducing temperatures. Although no experimental evidence indicated any degradation, the lubricating characteristics of Fabroid under high bearing loads had a tendency to fray and shed fibrous material.

Author

**N66-16193\*#** Materials Research Lab., Inc., Richton Park, Ill.

**ELEVATED TEMPERATURE STRESS CORROSION OF HIGH STRENGTH SHEET MATERIALS IN THE PRESENCE OF STRESS CONCENTRATIONS** Final Report

E. J. Ripling, R. L. Kirchner, R. P. O'Shea, and R. G. Lingwall Nov. 1965 47 p refs  
 (Contract NASr-50)

(NASA-CR-69851) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

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**N66-16194\*** Materials Research Lab., Inc., Richton Park, Ill.  
**THE DIFFUSION OF CORROSION PRODUCTS IN HOT SALT STRESS-CORROSION CRACKING OF TITANIUM** In its Elevated Temp. Stress Corrosion of High Strength Sheet Mater. in the Presence of Stress Concentrations Nov. 1965 p 2-19 refs (See N66-16193 07-17) CFSTI: HC \$2.00/MF \$0.50

An experimental technique is described for separating the gaseous, liquid and solid reaction products generated by the hot salt corrosion of titanium. By use of this procedure, it is shown that the product that causes cracking is not a gas, and hence would not be expected to be washed away by a fast moving air stream in service. Author

**N66-16195\*** Materials Research Lab., Inc., Richton Park, Ill.  
**ELECTROCHEMICAL ASPECTS OF HOT SOLID SALT STRESS CORROSION CRACKING OF TITANIUM BASE ALLOY**

In its Elevated Temp. Stress Corrosion of High Strength Sheet Mater. in the Presence of Stress Concentrations Nov. 1965 p 20-35 refs (See N66-16193 07-17) CFSTI: HC \$2.00/MF \$0.50

It is shown that the corrosion of titanium in the presence of hot solid salt occurs due to an oxygen differential cell. Cracking always occurs at the cathode of this cell, and the cracking can be prevented by impressing an anodic current on the stressed specimens. Author

**N66-16305\*** Oak Ridge National Lab., Tenn.  
**SNAP-8 CORROSION PROGRAM Summary Report**  
 W. R. Huntley et al Dec. 1965 223 p refs  
 (NASA Order C-220-A; Contract W-7405-ENG-26)  
 (NASA-CR-69822; ORNL-3898) CFSTI: HC \$6.00/MF \$1.25  
 CSCL 18N

To investigate the compatibility of the structural materials and NaK coolant in the SNAP-8 primary coolant circuit, a corrosion loop program was undertaken which used reduced-scale forced-flow loops that closely simulated the actual system. Loop design was primarily a chromized Hastelloy N heated section and Croloy 9M heat exchanger section connected by stainless steel. Eleven loop experiments were completed which accumulated about 25000 hr of operation at design conditions. In addition to an oxide break, plugging-indicator breaks were observed at 800 to 1100° F and 400 to 600° F; the first is believed to be due to argon and the precipitate in the second was not identified. A third plugging curve break was consistent with the cold-trap operating temperature and represented the design oxide level. Control of oxygen level varied with loop conditions. Studies indicate that loop exposures cause development of carbide and sigma phases. Additions of hydrogen to the NaK produce no detrimental effects, and the addition of 1 to 4 atm % lithium considerably diminishes the hydrogen activity. M.W.R.

**N66-16451#** Bureau of Mines, College Park, Md.  
**CORROSION PROPERTIES OF MOLYBDENUM, TUNGSTEN, VANADIUM, AND SOME VANADIUM ALLOYS**  
 Walter L. Acherman, J. P. Carter, C. B. Kenahan, and David Schlain 1966 73 p refs  
 (BM-RI-6715)

Molybdenum, tungsten, and vanadium were found by the Bureau of Mines to possess generally superior chemical and galvanic corrosion properties in many aqueous corrosion media at temperatures up to the boiling point. The corrosion resistance of vanadium in certain solutions was further improved by alloying it with such metals as columbium, tantalum, and titanium. Tungsten was susceptible to a type of crevice corrosion in mercuric chloride solutions, but no other instances of crevice corrosion were encountered. With few exceptions, molybdenum, tungsten, and vanadium were not adversely affected when coupled with dissimilar metals in galvanic corrosion experiments; in some cases one or both members of a couple were protected by contact. When exposed to aqueous

ammonia spray at 60°C, all three metals were moderately attacked, but they were resistant in spray environments of substitute ocean water and ammonium dihydrogen phosphate. Author

**N66-16581#** Bureau of Mines, Pittsburgh, Pa. Pittsburgh Coal Research Center.

**ANALYSIS OF LIGHT OILS FROM FLUIDIZED CARBONIZATION**

J. G. Walters and C. Ortuoglio 1966 34 p refs  
 (BM-RI-6709)

Analyses of light oils produced from the fluidized carbonization of coal at 485°, 550°, 600°, and 660°C are presented. Tar vapors from 485°C fluidized carbonization were thermally treated at 600°, 700°, and 800°C, and the analyses of light oils produced by this treatment are also presented. Procedures were developed for analysis of coal carbonization light oil by gas chromatography to permit a more definitive analysis than can be obtained by the conventional distillation procedure. An increase in low-boiling olefins, benzene, and toluene, a decrease in low-boiling paraffins, and little change in the remainder of the aromatics was observed with increased temperature of carbonization. Author

**N66-16588#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**FRICTION AND WEAR CHARACTERISTICS OF POLYIMIDE AND FILLED POLYIMIDE COMPOSITIONS IN VACUUM (10<sup>-10</sup> mm Hg)**

Donald H. Buckley Washington, NASA, Feb. 1966 13 p refs  
 (NASA-TN-D-3261) CFSTI: HC \$1.00/MF \$0.50 CSCL 11D

The friction and wear characteristics of polyimide and filled polyimide compositions were examined in a vacuum environment (10<sup>-10</sup> mm Hg). Copper-filled (to 50 weight percent) compositions as well as graphite- and molybdenum-disulfide-filled compositions were studied. Friction and wear experiments were conducted with a 3/16-inch-radius hemispherical rider sliding on a flat disk, which was rotated to produce sliding speeds to 1800 feet per minute. The polyimide was loaded against the disk (various metals) under a load of 1000 grams. The results of the investigation indicate that, to obtain effective lubrication (low friction and wear), a transfer of the polyimide film to the mating surface must be achieved. In its absence, high friction occurred with all polyimide materials. With copper addition, a minimum in wear rate was obtained at 30 weight percent copper. Both friction and wear increased with the addition of graphite as a filler to the polyimide. With the addition of molybdenum disulfide, marked decreases in both friction and wear occurred. Author

**N66-16738#** Naval Research Lab., Washington, D. C.  
**FACTORS AFFECTING THE ICING RESISTANCE OF LUBRICANTS FOR AIRCRAFT ORDNANCE Final Report**  
 H. R. Baker and R. N. Bolster 21 Oct. 1965 38 p refs  
 (NRL-6329; AD-624594) CFSTI: HC \$2.00/MF \$0.50

Recent samples of the all-weather semifluid lubricant for aircraft ordnance, both from manufacturers and from Navy stocks, have failed to meet the cold-sweat-cold gun firing test required by Military Specification MIL-L-19701 (NOrd). These failures were due to ice adhesion attendant on the poor water resistance of the lubricants. The probable cause of the loss in water resistance was the presence in the lithium stearate thickener of surface-active impurities such as sodium soaps and soaps of myristic and oleic acids. These impurities can be detected by measurements of surface tension lowering. It is probable that the water resistance of other lithium stearate thickened greases are also affected by these impurities. The investigation established that variations in raw materials other than the soap were not major contributors



to the difficulties encountered. A lubricant of altered formulation has been developed and shown to be superior to the original lubricant. Variations in the consistency of the improved lubricant over a wide temperature range were found to be much less than those of the original lubricant. Resistance to water and to ice adhesion are increased. This material has successfully lubricated the Mk 12 machine gun equipped with the Mk 7 pneumatic feeder under ambient temperature and cold-sweat-cold conditions. This formulation retains all of the useful properties of the original lubricant, such as compatibility with MIL-P-5516 oil-resistant rubber, resistance to evaporation loss, corrosion inhibition, and antiwear protection. Author (TAB)

**N66-16816#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PECULIARITIES OF CREATION OF HEAT-RESISTANT FRICTIONAL MATERIALS**

G. A. Georgiyevskiy 18 Nov. 1965 30 p refs Transl. into ENGLISH from the book "Povysheniye Effektivnosti Tormoznykh Ustroystv Svoystva Friksionnykh Materialov" Moscow, Akad. Nauk. 1959 p93-109

(FTD-MT-64-483; AD-624760) CFSTI: HC \$2.00/MF \$0.50

Principles of creation of frictional materials for work at high temperatures and pressures reduce to the following: use the friction series and series of wear-resistance to make the selection of friction ingredients; with this the thermal conductions and the influence of ingredients on counterbody of the friction pair should be taken into account. The binder should be heat-resistant, should preserve good elastic properties at high temperatures, and also should possess the ability to form coke-like products with good mechanical properties. The binder should have high adhesional properties. The content of organic binding should be minimum; this favors application of ingredients with little developed active surface. Increase and stabilization of coefficient of friction can be attained by: (a) introduction of oxidizers, promoting a lowering of the formation of liquid products of destruction and retaining the reduction of reactors; (b) additional heat treatment of friction material at a temperature of 400-600 degrees without an oxidizing medium. Every recommendation should be carried out in such a manner as to ensure the creation of frictional layer as a result of the use of heat emitted during braking.

Author (TAB)

**N66-17119#** Naval Civil Engineering Lab., Port Hueneme, Calif.

**POTENTIOSTATIC CORROSION STUDIES OF IRON, TYPE-304 AND TYPE-321 STAINLESS STEEL** Technical Report, Jun. 1964-May 1965

Howard A. Porte Dec. 1965 40 p refs

(R423; AD-624269) CFSTI: HC \$2.00/MF \$0.50

Important in the control and prevention of corrosion, electrochemical characteristics of iron and two types of stainless steel in various electrolyte systems were investigated as part of a long-range study of the mechanisms of the electrochemical and physical transformations that occur at electrode-electrolyte interfaces. The anodic potentiostatic polarization of iron was investigated in deaerated 1N sulfuric acid, deaerated and aerated borate buffer solution (pH 8.4), and in deaerated and aerated seawater. The effects of potential rate change and chloride ion concentration on polarization characteristics were studied in the borate buffer and sulfuric acid solutions. Polarization curves were determined for Type-321 stainless steel in deaerated 1N sulfuric acid and in deaerated borate buffer; the effect of chloride ion concentration was studied in both solutions. Polarization experiments were performed on Type-304 stainless steel in deaerated 1N sulfuric acid; the effect of cathodic pretreatment was studied.

Electrochemical polarization curves have proved to be useful in predicting which of a group of alloys would be the most corrosion resistant in a particular environment. Author (TAB)

**N66-17358#** National Aeronautics and Space Administration, Washington, D. C.

**BIBLIOGRAPHY ON SOLID LUBRICANTS, WITH INDEXES** Feb. 1966 34 p

(NASA-SP-5037) CFSTI: HC \$1.00/MF \$0.50 CSCL 11H

An annotated bibliography from the collections of TPA, STAR, and IAA entries, covering the years 1962 to 1964, designed to assess and identify literature on the applications and uses of solid lubricants is presented. A subject index and personal author index are included. L.S.

**N66-17405#** United Nuclear Corp., White Plains, N. Y. SODIUM TECHNOLOGY

Kurt Goldmann and Bertram Minushkin /in Argonne Natl. Lab. Reactor Technol. Jan. 1966 p 321-425 refs (See N66-17404 08-22) CFSTI: \$4.50

Sodium technology developed in conjunction with the design construction, and operation of liquid-metal-cooled reactor plants is reviewed. These power plants have an inherent capability of producing steam in the 500° to 900° F range with maximum liquid-metal temperatures of 600° to 1000° F. Also, the state-of-the-art of sodium technology is reviewed for the next-generation of power plants which are projected to have a capability of producing steam at 1050° F with maximum liquid-metal temperatures of 1200° to 1300° F. Materials selection, corrosion, control of sodium purity, and the experience gained in these areas with operating plants are examined in detail and other aspects of sodium technology such as sodium components, safe handling procedures, and heat transfer are briefly summarized. E.E.B.

**N66-17440#** Defense Dept., Washington, D. C. Office of the Director of Defense Research and Engineering.

**PROCEEDINGS OF AEROSPACE SYMPOSIUM ON LUBRICATING TECHNIQUES AND DESIGN STUDIES OF BEARINGS AND GEARS FOR AN ORBITAL MANNED SPACE LABORATORY**

[1965] 63 p refs Symp. held in Detroit, 7 May 1965 Sponsored by DOD and Am. Soc. of Lubrication Engr.

(AD-623336) CFSTI: HC \$3.00/MF \$0.75

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**N66-17441** Lockheed Missiles and Space Co., Sunnyvale, Calif. Material Sciences Lab.

**FLUID LUBRICATION OF DOOR ACTIVATORS FOR MANNED ORBITAL SPACE STATION**

Francis J. Clauss /in Defense Dept. Proc. of Aerospace Symp. [1965] p 3-4 refs (See N66-17440 08-15) CFSTI: HC \$3.00/MF \$0.75

The hypothetical door mechanism of a MOL was studied for its performance with various lubricants. The system was separated into area #1 including all parts from the drive motor up, and area #2 included the pinion gear and all parts of the telescoping rack. Oil and greases was found most desirable for lubrication in area #1, whereas bonded molybdenum disulfide film and self-lubricating composite materials were preferable to oils and greases in area #2. G.G.

**N66-17443** Midwest Research Inst., Kansas City, Mo.  
**LUBRICATING DOOR ACTIVATORS ON A MANNED ORBITAL SPACE STATION USING ONLY SOLID LUBRICANTS**  
Vern Hopkins, Ron Hubbell, Mahlon Campbell, and Roger Schroeder / *In* Defense Dept. Proc. of Aerospace Symp. [1965] p 9-24 refs (See N66-17440 08-15) CFSTI: HC \$3.00/MF \$0.75

This paper presents an approach to the use of solid lubrication on door activators in a hypothetical manned orbital space station. A design configuration for a worm-gear activator mechanism is given, and types of lubricants and lubricating methods for the individual components are discussed. Author

**N66-17533#** Ohio State Univ. Research Foundation, Columbus. Dept. of Metallurgical Engineering.  
**A STUDY OF THE MECHANISM OF STRESS CORROSION CRACKING IN THE IRON-NICKEL-CHROMIUM ALLOY SYSTEM** Quarterly Report, 17 Mar.-16 Jun. 1965  
R. W. Staehle, F. H. Beck, M. G. Fontana, and J. P. Hirth  
9 Jul. 1965 43 p ref  
(Contract AT(11-1)-1319)  
(COO-1319-27) CFSTI: HC \$2.00/MF \$0.50

The addition of 17 different elements as fourth-components in the Cr-Fe-Ni alloy system caused stress-corrosion cracking in all cases. Tests in combinations of water, chloride, and oxygen at 600° F indicate that both chloride and oxygen are necessary for accelerated surface attack. Tensile properties were determined from room temperature to 1200° F for selected alloys. An increase in strength with increasing chromium content was noted. Electron micrographs of oxide films revealed a distinct difference between those on low- and high-nickel alloys. NSA

**N66-17611#** Library of Congress, Washington, D. C. Aerospace Information Div.  
**CURRENT INFORMATION ON FUELS AND LUBRICANTS**  
**Surveys of Soviet-Bloc Scientific and Technical Literature**  
12 May 1964 13 p refs Compilation of Abstracts / *Its Rept.* - 30  
(AID-U-64-37; AD-623248) CFSTI: HC \$1.00/MF \$0.50

A review consisting of extracts, summaries, abstracts, and comments is given of Soviet developments in lubricants and fuels. In the study of liquid metal lubricants, the corrosiveness, hygroscopicity, and antiwear properties of a series of inorganic salts in their mixtures were investigated. Chlorides and bromides are reported to possess the best antiwear properties. Also mentioned were: (1) the receptivity of base oils to additives; (2) the suitability of liquid polysiloxanes as fluid bases in high temperature greases; and (3) the effects of sulfur and dichloroamine B additives on base oils. In the study of diesel fuels and gasolines, the effect of carbamide dewaxing on hydrofined and unhydrofined oils was determined. Also, the conditions were determined under which dewaxing could take place without loss of carbamide activity. Finally, a method for the systematic analysis of microcontaminants in jet fuels is outlined. D.T.

**N66-17654#** Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.  
**FRICTION AND WEAR BETWEEN UNLUBRICATED METAL AND NONMETAL SURFACES**  
William Wolkowitz and Barry E. Ranish Sep. 1964 51 p refs (RM-239; AD-475570)

An investigation has been made of the friction and wear characteristics of metal-to-metal and metal-to-nonmetal couples. The metals used were SAE 4620 and 1018 steel, and 7075-T6 and 2014-T6 aluminum alloy; the nonmetals were igneous rocks, i.e., rhyolite and basalt. Tests were made in air, vacuum, and argon. Both constant loading and continuously increasing loading were used. Two kinds of motion were employed—continuous and oscillatory sliding. The continuous sliding tests were conducted on a modified Alpha-Molykote friction tester at two speeds—4.5 and 26.0 ft/minute. The oscillatory sliding tests were made on a Grumman designed and built, ultrahigh vacuum friction tester at speeds ranging from 0.33 to 6.0 ft/minute. Author (TAB)

**N66-17717\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.  
**DRY FILM LUBRICANTS**  
J. E. Kingsbury and E. C. Mc Kanna / *In* its Symp. on Technol. Status and Trends 1966 p 101-104 refs (See N66-17706) 08-15) GPO: HC \$1.50; CFSTI: MF \$1.25

The stimulus for the development of dry film lubricants was provided by the unsatisfactory condition created when commercial liquid lubricants were exposed to the multiple environs of space. In the search for a satisfactory solution to lubrication in space, dry films were investigated. The dry film lubrication concept has proven most desirable for space, and a natural fallout is the potential shown by such films for consumer item application. On the acceptance that the coefficient of friction of dry films is not equivalent to that of a liquid lubricant under ideal conditions, this paper discusses how the ideal condition for liquid lubrication is rarely achieved in practical applications. Comparisons are made between the performance of dry film and liquid lubricants as a function of temperature, environmental pressure, and life. Furthermore, consideration is given to the comparative costs of liquid versus dry film lubricants to show the practicality and desirability of dry film lubrication to consumer items. Author

**N66-17779#** Joint Publications Research Service, Washington, D. C.  
**ZIRCONIUM AND ITS ALLOYS**  
11 Oct. 1965 36 p refs Transl. into ENGLISH from Russian periodicals  
(JPRS-32341; TT-65-32831) CFSTI: \$2.00

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1. VISCOSITY OF LIQUID ZIRCONIUM V. P. Yelyutin, M. A. Maurakh, and I. A. Pen'kov p 1-7 refs (See N66-17780 08-17)
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4. CORROSION OF ZIRCONIUM IN THE ALKALINE METAL CHLORIDE MELT V. P. Volodin, I. N. Ozeryanaya, and M. V. Smirnov p 24-31 refs (See N66-17783 08-17)

**N66-17783** Joint Publications Research Service, Washington, D. C.  
**CORROSION OF ZIRCONIUM IN THE ALKALINE METAL CHLORIDE MELT**

V. P. Volodin, I. N. Ozeryanaya, and M. V. Smirnov *In its Zirconium and Its Alloys* 11 Oct. 1965 p 24-31 refs Transl. into ENGLISH from *Elektrokhimiya Rasplavlennykh Soleykh i Tverdykh Elektrolitov*—Trudy Instituta Elektrokhimii (Sverdlovsk, USSR), no. 6, 1965 p 87-91 (See N66-17779 08-17) CFSTI: \$2.00

Results are presented of a study on the corrosion of zirconium in the molten equimolar mixture of potassium and sodium chlorides in relation to the temperature with the possible minimum inlet of oxidants. The research was performed by three methods: (1) the direct determination of the corrosion rate of zirconium according to the weight loss of the sample and the data of the melt chemical analysis; (2) by the computation of the corrosion current from the values of the equilibrium potential; and (3) according to the changes of anodic polarization. The temperature relationship of the zirconium equilibrium potential was found. It is shown that within the limits of possible experimental errors, the corrosion rate determined by the direct method conforms well with the corrosion rate computed from the values of equilibrium potentials and according to the anodic polarization curves. R.N.A.

**N66-17856#** Compagnie des Ateliers et Forges de la Loire, Paris (France). Dept. des Recherches.  
[MECHANICAL PROPERTIES OF STEELS] Quarterly Report No. 2, Jan.-Apr. 1965  
[1965] 43 p ref. Transl. into ENGLISH from the FRENCH (Contract EURATOM-033-64-9 TEEF (RD)) (EURAE-1397; EUR-2356) CFSTI: HC \$2.00/MF \$0.75

The mechanical properties at room temperature, the stress-corrosion in 42%  $MgCl_2$  solutions, and the stress-corrosion in  $MgCl_2$ -NaCl solutions as a function of pH were measured. The addition of silicon to the austenitic and austenoferritic steels increased the yield strengths and the stress-corrosion resistance to boiling  $MgCl_2$ . NSA

**N66-18080#** Metaalinstituut TNO, Delft (Netherlands).  
ANALYSIS OF A CORRODED STEEL SUPPORTING PLATE USING AN ELECTRON MICROSCOPE [ONDERZOEK VAN EEN GECORRODEERDE STEUNPLAAT MET BEHULP VAN DE ELECTRONENMICROSCOOP]  
J. M. Nijpjes and H. B. Zeedijk 28 Oct. 1965 10 p In DUTCH (M65-933; TDCK-43809) CFSTI: HC \$1.00/MF \$0.50

An electron microscope was used to study the products found in the matrix and on the surface of a steel supporting plate, and results of the qualitative analysis are presented. Data indicate that the corrosion products consist of a complex oxide, with the corrosion layer containing mostly Fe and Ni and, as minor components, Cr and V. The carbides in the supporting plate and in the basic materials are identified as  $Cr_{23}$  and  $C_6$ . Findings also show that the carbides are large in the supporting plate, and flat in the basic material where the carbides appear mainly on the edges of the disks. Transl. by J.O.

**N66-18172#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.  
DRAG AND WEAR CHARACTERISTICS OF VARIOUS SKID MATERIALS ON DISSIMILAR LAKEBED SURFACES DURING THE SLIDEOUT OF THE X-15 AIRPLANE  
Ronald J. Wilson Washington, NASA, Mar. 1966 28 p refs (NASA-TN-D-3331) CFSTI: HC \$0.40/MF \$0.50 CSCL 01C

An investigation was made to determine the coefficients of friction and the wear characteristics for X-15 landing-gear skids of various materials. Data are presented for skids made of 4130 steel, with and without cermet coating, and Inconel X for several lakebed-surface conditions. The mean coefficient of friction on a dry-hard surface was found to be 0.30 for 4130 steel skids, 0.36 for 4130 steel skids with cermet coating, and

0.35 for Inconel X skids. The mean coefficient of friction for the cermet-coated skids on a soft surface was 0.46; for Inconel X skids on a damp surface the mean value was 0.25. Flight data are compared with experimental ground-tow test data on natural and simulated lakebed surfaces. Also included is the variation of skid wear with slideout distance. Author

**N66-18181#** General Electric Co., Schenectady, N. Y. Advanced Technology Labs.  
EVALUATION OF THIN WALL SPACECRAFT ELECTRICAL WIRING. VOLUME II: TEST RESULTS AND FACILITIES  
Technical Report No. 1

L. J. Frisco and K. N. Mathes 28 Jul. 1965 204 p (Contract NAS9-4549) (NASA-CR-65233) CFSTI: HC \$6.00/MF \$1.25 CSCL 13H

Results of insulation resistance measurements on spools of wire immersed in wet oxygen are given for 1 minute and 5 minute electrification times. One specimen of each wire sample was also tested extensively at the end of the 3-day immersion to determine its resistance versus time of voltage application characteristics and to find dielectric losses at very low frequencies. Insulation resistance measurements on cabled, aged wires exposed to abrasion, radiation, offgassing in oxygen, etc., showed excellent agreement among specimens of the same wires. In general, taped wire constructions produced decreased insulation resistance, while extruded wires remained unaffected. G.G.

**N66-18224#** Battelle Memorial Inst., Columbus, Ohio.  
CORROSION PROTECTION OF THE HYDROFLUORINATOR BY AN INERT GAS SPARGE

P. D. Miller, L. K. Matson, and E. F. Stephan 5 Feb. 1965 20 p (Contract W-7405-ENG-92) (BML-X-329)

Several experiments were conducted to determine if an inert gas sparge just below the surface of the liquid would reduce the severe attack at the interface by diluting the HF in this area. In these experiments, the 52-37-11 mole % NaF-LiF-ZrF<sub>4</sub> salt with HF sparge was used at 650°C in 4-inch Hastelloy B and 2-inch INOR-8 containers with INOR-8 corrosion specimens. It was concluded that argon and helium sparge gases definitely reduced corrosion, but the data were inconsistent. Gas flow patterns and other variables may have an effect on the corrosion inhibition. NSA

**N66-18290#** Los Alamos Scientific Lab., N. Mex.  
HIGH-TEMPERATURE COMPATIBILITY TESTING OF MOLTEN PLUTONIUM FUEL-CONTAINER SYSTEMS

R. L. Andelin [1965] 5 p refs Presented at the 13th Conf. on Remote Systems Technol., Washington, D. C. (Contract W-7405-ENG-36)

(LA-DC-7316; CONF-651101-28) CFSTI: HC \$1.00/MF \$0.50  
The linear relation of Ta capsule lifetime versus temperature obtained for capsules containing Pu and Ga-stabilized Pu-2.5 wt% Fe fuels implies a constant failure mechanism with temperature. The capsules containing Pu had a much shorter lifetime. Carburization of the Ta capsule retarded the Pu intergranular penetration. No difference was observed when using high-purity Na (<1 ppm O<sub>2</sub>) or high vacuum ( $1 \times 10^{-7}$  torr) as external capsule environments during testing. NSA

**N66-18416#** Atomic Weapons Research Establishment, Aldermaston (England).  
URANIUM CORROSION STUDIES. PART 2: THE RATE OF REACTION OF POLISHED URANIUM AND WATER VAPOUR AT VARIOUS TEMPERATURES

J. H. Grimes and J. R. Morris Sep. 1965 27 p refs  
(AWRE-O-68/65) HMSO: 3s 3d

The rate of reaction of uranium and water vapor has been determined at temperatures in the range 30° to 80° C. An activation energy of 9 kcal/g mole has been derived. Comparisons are made between the rate of corrosion of uranium found by the measurement of oxide film growth and that found by other methods. Author

**N66-18493#** Bureau of Yards and Docks, Pearl Harbor, Hawaii, Pacific Div.

**THE OCCURRENCE AND PREVENTION OF CORROSION**

Willard E. Edwards Dec. 1965 11 p  
(AD-625900) CFSTI: HC \$1.00/MF \$0.50

The best time to provide protection against corrosion is during the planning, design, and construction stages. This is done through the proper choice of both materials and construction methods. Coatings and cathodic protection of steel may then be called for and used as required. After that, rigid maintenance practices, regularly performed by qualified personnel, are essential in order to realize the great savings which can be accomplished through corrosion mitigation. Whenever underground leaks occur in iron or steel pipes due to external corrosion, it is good insurance to install a magnesium anode at the same time that the leak is repaired. Cathodic protection will usually save many times its installation cost wherever it may be required in corrosive soils or water. TAB

**N66-18514#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**STUDYING THE EFFECT OF ADDITIONS TO POLYCAPROLACTAM "B" ON ANTIFRICTION PROPERTIES AND ADHESION TO METAL**

D. S. Makhmudov and A. N. Levin 15 Nov. 1965 14 p refs  
Transl. into ENGLISH from Tr. Inst. Khim. Mashinost. (Moscow), v. 27, 1964 p 194-200  
(FTD-TT-65-986/1+2+4; AD-625286) CFSTI: HC \$1.00/MF \$0.50

It is shown that the addition to polycaprolactam of aluminum powder, talcum, graphite and, in particular, molybdenum disulfide improves its antifriction properties and certain other physio-mechanical qualities. TAB

**N66-18519#** Ampex Corp., Redwood City, Calif.  
**INTERACTION BETWEEN SELF-ACTING AND EXTERNALLY PRESSURIZED EFFECTS IN A FOIL BEARING**  
E. J. Barlow Oct. 1965 24 p refs  
(Contract Nonr-3815(00)(X))  
(RR-65-12; AD-625762) CFSTI: HC \$1.00/MF \$0.50

For a foil bearing, the interaction between the flow of lubricant from feed holes and the flow in from the surrounding environment is calculated numerically. The results are applicable for a partial arc foil bearing whenever the feed holes are far from both ends of the wrap angle. The report extends the linearized solution into the nonlinear range. Author (TAB)

**N66-18520#** Aluminum Co. of America, New Kensington, Pa. Alcoa Research Labs.  
**FRACTURE TOUGHNESS, FATIGUE-CRACK PROPAGATION AND CORROSION CHARACTERISTICS OF ALUMINUM ALLOY PLATES FOR WING SKINS** Quarterly Report, 3 Sep.-3 Dec. 1965

G. E. Nordmark, B. W. Lifka, and J. G. Kaufman 15 Dec. 1965 43 p ref  
(Contract AF 33(615)-2012)  
(AD-625454) CFSTI: HC \$2.00/MF \$0.50

The fracture toughness, fatigue properties and corrosion resistance of 2020-T651, 2024-T851, 2219-T851 and

7001-T75 are being determined. Fracture-toughness tests of 1-in. specimens of the 2020-T651, 2219-T851 and 7001-T75 were completed during the past quarter. The fracture toughness of 2020-T651 is lowest; those of 7001-T75 and 2024-T851 are higher but still about 20 percent below that of 7075-T651 (from AF33 (657)-11155). The fracture toughness of 2219-T851 is exceptionally high, equalling or exceeding that of 7075-T7351. Fatigue tests of center-notched specimens of 2020-T651 and 2219-T851 are complete. Cracks initiate in about the same number of cycles for 2219-T851 as for 2024-T851, and slightly sooner than in 2020-T651 and 7075-T651. Cracks propagate more slowly in 2219-T851 and 2020-T651 than in some of the other alloys, but 2020-T651 fails at shorter crack lengths. Corrosion tests show that 2020-T651, 2024-T851 and 2219-T851 are highly resistant to exfoliation attack and to stress-corrosion cracking in any direction at stresses up to 75 percent of the yield strength, similar to the case for 7075-T7351. Author (TAB)

**N66-18539#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PROBLEM OF THE BEHAVIOR OF HEAT RESISTANT ALLOYS IN CONTACT WITH SODIUM IN STRESSED STATE**  
G. P. Benediktova and S. T. Kishkin 8 Dec. 1965 12 p Transl. into ENGLISH from Tr. Aviatzionny Inst. (Moscow), no. 158, 1964 p 29-34

(FTD-TT-65-1050/1+2+4; AD-625148) CFSTI: HC \$1.00/MF \$0.50

The article discusses stress corrosion of heat-resistant alloys in contact with Sodium containing admixtures. TAB

**N66-18553#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ON DETONATION COMBUSTION OF HETEROGENEOUS SYSTEMS**

V. Ye. Gordeyev, V. F. Komos, and Ya. K. Troshin 3 Dec. 1965 12 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR, v. 160 no. 4, 1965 p 853-856

(FTD-TT-65-1106/1+2+4; AD-625158) CFSTI: HC \$1.00/MF \$0.50

The transition from combustion to detonation of a thin layer of lubricating oil in an oxygen filled tube was studied, using a high speed photographic system to record the process. Various methods were used to initiate combustion, including shock waves and electric discharges. An investigation conducted to determine the amount of oil per unit area necessary for an accelerating combustion established two critical values, one corresponding to detonation and the other corresponding to explosion. Under the conditions of the experiments, combustion was observed to accelerate from 200 m/sec to 800 m/sec over a distance of 600 mm. D.T.

**N66-18554#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**DETERMINING THE ELASTICITY OF SATURATED VAPORS OF LUBRICATING MATERIALS**

V. M. Martynov and M. V. Morozova 3 Dec. 1965 16 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 12, 1963 p 62-65

(FTD-TT-65-1063/1+2+4; AD-625155) CFSTI: HC \$1.00/MF \$0.50

On the basis of experimental data, obtained during the study of elasticity of saturated oil and grease vapors, it can be concluded, that, if the oil or grease are designated for use within a period of long time in vacuum conditions, when the vapors of evaporating components do not effect the operation of the mechanisms, evaluation of the working period of the given lubricant will be insufficient by the value of the initial

vapor elasticity. The initial vapor elasticity depends upon the admixture of light components, the removal of which sharply reduces vapor elasticity.

TAB

**N66-18656#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**METHOD OF OBTAINING LUBRICANT FOR TITANIUM PARTS**

N. K. Sul'zhenko, V. P. Barannik et al 15 Dec. 1965 5 p Transl. into ENGLISH from Soviet Patent no. 166081 (Appl. no. 819801/23-4, 7 Feb. 1963) 1 p

(FTD-TT-65-1193; AD-625160) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is a method of obtaining a lubricant for titanium parts on the basis of crystalline iodide for preventing the seizing of fastened titanium parts and improving anticorrosion capacity. Oleic acid is subjected to interaction with crystalline iodine at a temperature of 85 degrees in the ratio of 1:1.

Author (TAB)

**N66-18773#** Du Pont de Nemours (E. I.) and Co. Aiken, S. C. Nuclear Materials Div.

**STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEEL Status Report, Period Ending 1 Sep. 1964**

McIntyre R. Louthan, Jr Feb. 1965 20 p refs

(Contract AT(07-2)-1)

(DP-957) CFSTI: HC \$1.00/MF \$0.50

Stress corrosion cracking of austenitic stainless steel is being investigated to develop a fundamental understanding of the phenomenon. The status of studies relating specimen microstructure and dislocation substructure to the susceptibility to stress corrosion cracking are presented. The results show that anodic dissolution plays a major role in the nucleation and propagation of stress corrosion cracks. The susceptibilities of different heats of the same type of steel to cracking are quite different, and these differences are not attributable to differences in the composition of major alloying elements, material hardness or dislocation substructure. It is also shown that the relative rate of preferential attack at dislocation arrays and stacking faults in thin foils of type 304 stainless steel exposed to dilute NaCl solutions increased with increasing temperature and was more rapid in heats of steel which were most susceptible to cracking in bulk tests.

Author (NSA)

**N66-18846# Mechanical Technology, Inc., Latham, N. Y. A THEORY FOR TURBULENT FLUID FILMS AND ITS APPLICATION TO BEARINGS**

H. G. Elrod, Jr., C. W. Ng, and C. H. T. Pan Mar. 1965 73 p refs

(Contract AT(30-1)-3363)

(NYO-3363-2; MTI-65TR9) CFSTI: HC \$2.00/MF \$0.75

A new turbulent lubrication analysis was derived which takes into account certain well-established facts concerning turbulent shear flow. Consistent with lubrication-film theory, the nature of the local flow is taken to depend only on local film thickness, surface velocity, and pressure gradients. An eddy diffusivity treatment is used which incorporates the "law of wall" with the use of local (within the film) shear stress. Stress reversal phenomena are accommodated, and isotropy of the turbulent exchange mechanism in the plane of the film is assured. Coefficients are developed for use in the generalized Reynolds (lubrication) equation, and computation procedures for the static and dynamic characteristics of turbulent, self-acting bearings have been prepared. The non-linear effects due to the coupling of the shear-induced flows and the flows due to the circumferential and axial pressure gradients are fully considered in this analysis. Thus, it is anticipated that it, unlike the previous linearized analysis, is directly applicable also to turbulent, externally pressurized and hybrid bearings.

Author (NSA)

**N66-18857# Bettis Atomic Power Lab., Pittsburgh, Pa. TEST RIG FOR USE IN WEAR AND FRICTION STUDIES IN A WATER ENVIRONMENT**

N. B. Dewees Mar. 1965 39 p refs

(Contract AT(11-1)-GEN-14)

(WAPD-288) CFSTI: HC \$2.00/MF \$0.50

A test rig is described for measuring the rate of wear and the coefficient of friction for materials tested in a pressurized water environment at temperatures to 500°F. The rig operates with either a continuous sliding or an oscillating motion. Two different designs of specimens are tested simultaneously to show in a single test whether loading or design of specimens may significantly affect test results. Tests can be performed with a unit loading on the wear surfaces of 30 to 9000 psi with the standard specimens. Evaluation of a material combination is based upon relative wear rates between the two types of specimens as well as the magnitude and trend of wear rate and roughness in successive test intervals. Examples are given for material combinations having widely different performance.

Author (NSA)

**N66 18864# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Suresnes (France). Division Atomiques. PROGRESS OF WORK DURING THE FOURTH QUARTER 1964 Quarterly Report No. 19**

C. Moussez 11 Jan. 1965 9 p Transl. into ENGLISH from French

(Contract EURATOM-061-64-7TEEF)

(EURAC-1288) CFSTI: HC \$1.00/MF \$0.50

Progress is reported in measurements of 20 mm-dia. circular channel pressure drop, flow quality, and corrosion film thickness. Tests on a 2-channel cruciform section are discussed. Thermal studies on a 20-mm circular section with evolutive flux are discussed along with studies on a test section with direct heating by Joule effect. A test section with nine heating rods was designed.

NSA

**N66-18872# Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires.**

**ELECTROMAGNETIC CIRCULATION PUMP FOR CORROSIVE GASES [POMPE DE CIRCULATION ELECTROMAGNETIQUE POUR GAZ CORROSIFS]**

Pierre Noe, Denise Delafosse, and Gerard Deletre Feb. 1965 16 p In FRENCH

(CEA-R-2744)

In order to transport very corrosive products (fluorinated compounds), a totally metallic circulation pump capable of operating at above room temperatures and with a molecular vacuum was developed. Maximum simplicity was the primary aim both in conception and operation. The tests showed that the compression ratios produced, although not high, are interesting (1.5 at a pressure of 100 torr). The flow-rate range is very wide: about one hundred ccs/atm/min. to 3,000 ccs/atm/min. Desorption of the pump presents no difficulty if both the aspiration and the reject sides are pumped together. A hole of 2 mm diameter drilled in the piston makes it possible to desorb the space between the two segments. The price of the pump is 1,300 F, with the electrical cabinet.

Author (NSA)

**N66-18889# Battelle-Northwest, Richland, Wash. Reactor and Materials Technology Dept.**

**CORROSION OF ZIRCALOY-2, WEAR AND CREVICE EFFECTS**

W. K. Winegardner 25 Aug. 1965 6 p refs Presented at the Meeting of the Inland Empire Sect. of the Natl. Assoc. of Corrosion Engr., 17 Sep. 1965

(Contract AT(45-1)-1830)

(BNWL-SA-313)

The localized corrosion of Zircaloy-2 by wear or fretting and crevices in the PRTR is discussed. It is concluded that

wear and concentration of lithia in heated crevices can initiate localized corrosion of Zircaloy-2 reactor core components.  
NSA

**N66-18899#** Westinghouse Electric Corp., Pittsburgh, Pa. Research Labs.

**INVESTIGATION OF CORROSION FILMS ON INCONEL AND AISI TYPE 304 STAINLESS STEEL BY TWO NEW TOOLS: THE SPINNING-SOURCE MASS SPECTROGRAPH MICROPROBE AND THE SCANNING ELECTRON MICROSCOPE**

W. M. Hickam, G. G. Sweeney, and W. T. Lindsay, Jr. Jan. 1965 28 p refs Prepared for Bettis Atomic Power Lab.

(Contract AT(11-1)-GEN-14)

(WERL-1114-1) CFSTI: HC \$2.00/MF \$0.50

The results of a preliminary study on the use of the spinning-source mass spectrograph microprobe and the scanning electron microscope to investigate surfaces of Inconel and AISI type 304 stainless steel corroded in high temperature water are reported. The results showed that the scanning electron microscope has great potential usefulness for the study of corrosion reactions. This results in part from the unusual contrast-producing process, which can reveal surface features not easily distinguished by other means, and in part from the fact that the examination is nondestructive and does not require surface replication. The spinning-source mass spectrograph microprobe in its present state of development is less suited to sampling very thin ( $<1\mu$ ) oxide films than to thin layers of unoxidized metal. NSA

**N66-18903#** Atomics International, Canoga Park, Calif.  
**EFFECT OF EXTENDED EXPOSURE TO HEATED LIH ON TENSILE PROPERTIES OF 347 AND 321 STAINLESS STEELS**

R. S. Neymark 7 Jan. 1965 35 p refs

(Contract AT(11-1)-GEN-8)

(NAA-SR-MEMO-10885)

Tensile specimens of Type 321 and of Type 347 stainless steel that which were exposed in LiH exhibited similar tensile properties to control specimens that were concurrently exposed in helium. The elongation observed in several test conditions with both Types 321 and 347 was as low as 18 to 20%, whether exposed in LiH or in helium. Type 316 had exhibited minimum elongations of about 22 to 23% under equivalent exposure and test conditions, and would be preferred over Types 321 or 347 if maximum ductility under all conditions was essential. Weight changes were determined for tabs of Type 347, 316, and 19-9 DL, which were included in the LiH with the tensile blanks. Type 316 had the smallest weight change and 19-9 DL the greatest, but none corroded appreciably (the maximum rate was less than 0.0004 inches per year). NSA

**N66-18939#** Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering.

**THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION**  
Quarterly Report No. 4

B. N. Ferry Jun. 1965 16 p ref

(Contract AT(40-1)-3208)

(EURAC-1424) CFSTI: HC \$1.00/MF \$0.50

The percentage of nitrogen dissolved in type 304 stainless steel was measured as a function of the nitriding time at 1000° F for different ammonia-hydrogen ratios. This information enables nitriding and diffusion anneal treatments to be combined. Two torsional pendulum experiments were performed and the relaxation spectrum obtained for unnitrided type 304 stainless steel at 0.50 cps frequency. No internal friction peaks occurred between 80 and 423° F. The mean internal friction (logarithmic decrement) values were 0.0016 for the first and 0.0021 for the second experiments. NSA

**N66-19008#** College of Aeronautics, Cranfield (England).  
**MINIMUM HYDRODYNAMIC OILFILM THICKNESS: AN EXPERIMENT AND THEORETICAL INVESTIGATION**

B. R. Reason Aug. 1965 23 p refs

(CoA-AERO-184) CFSTI: HC \$1.00/MF \$0.50

The paper deals with an experimental and analytical investigation of the lowest limit of hydrodynamic film thickness compatible with the condition of 'running in'. Using the working geometry of an experimental test rig together with the two dimensional Reynolds equation, an analytical expression for the minimum hydrodynamic film thickness has been developed. The problem has been investigated from an experimental standpoint using a measuring system based on an air gauge and capable of detecting film thickness changes of the order of  $10^{-6}$  inches. Although calculations of the magnitude of the minimum hydrodynamic oilfilm thickness gave values as low as  $5 \times 10^{-6}$  inches, the minimum value obtained experimentally was  $2.5 \times 10^{-5}$  inches. Author

**N66-19104\*#** National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va.

**SALT STRESS CORROSION OF RESIDUALLY STRESSED Ti-8Al-1Mo-1V ALLOY SHEET AFTER EXPOSURE AT ELEVATED TEMPERATURES**

Howard B. Dexter Washington, NASA, Mar. 1966 22 p refs  
(NASA-TN-D-3299) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

An experimental investigation of the salt-stress-corrosion cracking of residually stressed Ti-8Al-1Mo-1V alloy sheet (duplex annealed) has been carried out with bend specimens which were brake formed from 0.050-inch-thick sheet over dies with radii of 0.25, 0.5, 1, 1.5, and 2.5 inches; residual tensile stresses ranged from 25 to 65 ksi. Specimens were salt dipped in a 3.4-percent NaCl solution and exposed at temperatures from 400° to 600°F for times up to 6400 hours. Severe stress-corrosion cracking was found to occur after 20 hours exposure at 600°F for the 0.25-inch-radius specimens, but no salt stress corrosion was noted at 400°F regardless of stress. Salt stress corrosion after 3200 and 6400 hours exposure began to occur at temperatures above 400°F for the bend radii investigated. Additional tests were run to determine the relative effects of NaCl, CaCl<sub>2</sub>, MgCl<sub>2</sub>, sea salt, and simulated sea salt (seven parts NaCl to one part MgCl<sub>2</sub>) on stress-corrosion cracking. The results showed NaCl to be the most corrosive. Conventional stress-relieving procedures were effective in eliminating stress corrosion when performed in an argon environment, but results were erratic when the specimens were stress relieved in air. Author

**N66-19189#** Defence Research Board, Ottawa (Ontario).  
Directorate of Scientific Information Services.

**CATHODIC POLARIZATION OF SPENT ZINC-CONTAINING PAINTS IN SEA WATER**

A. G. Khanlaroua, M. R. Khanmamedoua, and M. A. Ibrahimova  
May 1965 14 p refs Transl. into ENGLISH from Lakokrasochnyye Materialy i Ikh Primenenie (Leningrad), v. 3, 1964 p 34-37

(T-424-R) CFSTI: HC \$1.00/MF \$0.50

Studies were undertaken to establish the dependence of protective zinc paints upon the chemical composition of the electrolyte. Paint coatings of 90% zinc and 10% polystyrene were tested in solutions of NaCl, KCl, Na<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>SO<sub>4</sub>, and MgSO<sub>4</sub> for two months. Tabulated data show the alterations of the electrode potential after exposures at various time periods. Experiments on the cathodic polarization of spent zinc paint coatings in sea water showed that their polarizability depends both on the chemical composition of the binder, and on the degree to which the zinc is spent. Maximum cathodic polarizability was found in paint coatings with chlorinated rubber and polystyrene bases. The deduction was made that the protective action of spent zinc paint coatings

can be restored by brief cathodic polarization with currents of small density. It was concluded that the use of cathodic protection simultaneously with protective coatings of zinc paint reduced the electric current expenditures, and increased the period of effectiveness of the paint coatings. N.E.N.

**N66-19192#** Mechanical Technology, Inc., Latham, N. Y.  
**FRICTION AND LUBRICATION AT EXTREME PRESSURES**  
 Interim Report

M. B. Peterson and F. F. Ling 2 Dec. 1965 67 p refs  
 (Contract Now-65-0363-c)  
 (MTI-65TR59)

A theoretical and experimental program is being conducted to better define the frictional process in hot metal deformation. The initial portion of this program was directed toward gaining a better understanding of friction at the extreme pressures characteristic of metal working. To do this a simple bench test was used. A foil of metal (workpiece) is compressed between an anvil and a flat plate. When a force is applied to the anvil, slip takes place between the metal and the flat. Using this device, the coefficient of friction was determined for pure metals for pressures to 200,000 psi and temperatures to 1000° F. Three regions of friction were found: classical friction; deformation friction, where the friction is completely defined by plastic deformation; and thin film friction, in which shear rate effects are hypothesized. An analysis was made of two modes of deformation and compared with experimental results. A study of pure metal lubrication was conducted. It is proposed that the effectiveness of a lubricant for a given metal can be based upon its ability to withstand the wear of the deforming metal.

Author

**N66-19245#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**NEW ANTIFRICTION AND CHEMICALLY STABLE MATERIALS**

S. N. Ganz and V. B. Parkhomenko 1 Dec. 1965 15 p Transl. into ENGLISH from Khim. Prom. Nauk Tekhn. Zb. (Kiev), no. 4, 1963 p 20-24  
 (FTD-TT-65-857/1+2+4; AD-625092) CFSTI: HC \$1.00/MF \$0.50

A description is given of new types of antifriction and chemically stable materials, manufactured on the basis of fluoroplast-4 (a polytetrafluoroethylene), where molybdenum disulfide, boron nitride, barium sulfuric acid, colloidal graphite type S-1, ground coke, pure anhydrous aluminum oxide and gas channel soot were used as fillers. These materials can be used in role of self-greasing piston rings, slide bearings, packing elements, etc. Their application will offer the possibility of replacing stainless steel, pure aluminum, antichlor and other deficit and high cost materials in chemical apparatus and machine construction.

Author (TAB)

**N66-19381#** Mechanical Technology, Inc., Latham, N. Y.  
**STRESSES IN LUBRICATED ROLLERS CONSIDERING ARBITRARILY DISTRIBUTED NORMAL AND TANGENTIAL LOADS**  
 H. S. Cheng and R. J. Wernick Dec. 1965 28 p refs  
 (Contract Nonr-3279(00))  
 (MTI-65TR61; AD-626008) CFSTI: HC \$2.00/MF \$0.50

A numerical solution to the stresses in lubricated rollers considering arbitrarily distributed normal and tangential loads is obtained. Results are obtained for rollers operating in the elastohydrodynamic regime with and without sliding. The effect of a small amount of slip in the contact is shown to be significant.

Author (TAB)

**N66-19382#** Frankford Arsenal, Philadelphia, Pa.  
**STRESS-CORROSION SUSCEPTIBILITY OF ULTRAHIGH STRENGTH STEEL EVALUATED IN TERMS OF FRACTURE TOUGHNESS**

Joseph H. Mulherin and Edward H. Hess Nov. 1965 35 p refs  
 (R-1782; AD-626013) CFSTI: HC \$2.00/MF \$0.50

The stress-corrosion susceptibility of several ultrahigh strength ferrous alloys is described on the basis of fracture mechanics parameters. Two general conditions were considered: first, the susceptibility of a material at various levels of tensile yield strength and fracture toughness; and second, susceptibility as a function of applied subcritical stress intensity levels. Experimentally, a notched and fatigue-cracked bendbar specimen configuration was used. Under a subcritical load, fracture of the specimen occurs upon sufficient environmentally influenced crack extension. The susceptibility criterion adopted in this investigation was the time period to catastrophic fracture of the specimen. The results are evaluated in terms of strength level and fracture toughness, and the usefulness of the data generated is examined in terms of material evaluation and application.

Author (TAB)

**N66-19466#** Coating and Chemical Lab., Aberdeen Proving Ground, Md.  
**EXTENDED USE OF IMPROVED COOLING SYSTEM INHIBITOR—FIELD EVALUATION** Interim Report

James H. Conley 3 Dec. 1965 12 p refs  
 (CCL-190; AD-625928) CFSTI: HC \$0.50/MF 0.50

The object of this investigation is to determine if Federal Specification 0-1-490a, Corrosion Inhibitor is suitable for use in vehicle cooling systems for extended periods. The improved inhibitor was placed in the vehicle cooling systems with antifreeze compounds meeting Federal Specification 0-A-548a, Type I, or commercial materials similar to the Type I. The inhibitor was added at the rate of 1 ounce per 2 quarts of water used in making up the antifreeze solution. Four government vehicles and four private passenger cars were utilized for test. Solutions were checked every three months and if necessary the coolant freezing point, pH value and reserve alkalinity (R.A.) value were adjusted. Data indicate that inspection periods of longer than three months permits the coolant to get out of control. In the event the Army adopts the continued use of antifreeze solutions for two years, the coolant solutions must be checked every three months by technical personnel and adjusted, if necessary, to insure safe continued use.

Author (TAB)

**N66-19474#** Socony Mobil Oil Co., Paulsboro, N. J.  
**STUDY AND EVALUATION OF THE OXIDATIVE AND DEPOSIT-FORMING PROPERTIES OF HIGH TEMPERATURE LUBRICANTS**

S. J. Leonardi and E. A. Oberright Wright-Patterson AFB, Ohio, AF Aero Propulsion Lab., Nov. 1965 26 p refs  
 (Contract AF 33(615)-1367)  
 (AFAPL-TR-65-85; AD-625833) CFSTI: HC \$2.00/MF \$0.50

A series of high temperature oils was evaluated in a high temperature thin film oxidation unit. The apparatus measures oxygen consumption and deposits formed by the oils in thin films on a rotating heated disk. The test exhibited excellent correlation with deposit formation in a jet engine. To simplify the selection of conditions for future testing requirements, the effects of several test variables were evaluated. These include test time, oil circulation rate, oxidation of the sump oil, dispersion of the sump air, and effects of metals in the sump.

Author (TAB)

**N66-19515\*** Aerojet-General Corp., Azusa, Calif. SNAP-8 Div.

**SNAP-8 MATERIALS REPORT FOR JANUARY-JUNE 1965**  
H. Derow and B. E. Farwell Jul. 1965 83 p refs /ts Rept.-3038

(Contract NAS5-417)

(NASA-CR-54719) CFSTI: HC \$3.00/MF \$0.75 CSCL 18N

Investigations were conducted in support of the design, fabrication, and development testing of various SNAP-8 components. Investigation of a mercury forced-convection corrosion loop was continued with the aim of evaluating the corrosion resistance of 9Cr-1Mo alloy steel (the reference mercury-containment material) for 10,000-hour service. Rubidium is being evaluated as an additive to the mercury to promote boiler conditioning. Data were developed in a continued program to evaluate the effect of the SNAP-8 operating environment on 9Cr-1Mo steel. Author

**N66-19560#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ADDITIVE TO SULFUROUS FUEL**

M. I. Shapovalov 8 Dec. 1965 5 p Transl. into ENGLISH from Soviet Patent no. 157034 (Appl. no. 755907/23-5, 15 Dec. 1961) 2 p

(FTD-TT-65-1126/1+4; AD-625248) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is an additive to sulfurous fuel on the basis of tricresylphosphate and nitrobenzene which has the distinguishing feature that, for the purpose of reducing the wear on the piston cylinders and lessening the scale formation, there are introduced isopropyl spirits and chromium nitrate. Author (TAB)

**N66-19561#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ADDITIVE TO SULFUROUS FUELS FOR HIGH-SPEED DIESEL ENGINES**

N. A. Butkov, P. A. Sukhorukov, Ye. A. Kazmina, P. P. Botkin, and V. S. Yamburenko 8 Dec. 1965 5 p Transl. into ENGLISH from Soviet Patent no. 155359 (Appl. no. 783879/24-6, 22 Jun. 1962) 2 p

(FTD-TT-65-1125/1+4; AD-625246) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is an additive to sulfurous fuels for high-speed Diesel engines, which has the distinguished feature that, for the purpose of lowering the scale formation and wear of the engines, as an additional active component barium naphthenate is introduced in the amount of 0.6% with a corresponding lowering in the content of deparaffined heavy gas oil from 91% to 90.4%. TAB

**N66-19564#** Southwest Research Inst., San Antonio, Tex. **LUBRICATION RESEARCH FOR AERO PROPULSION SYSTEMS** Phase Report No. 1, Feb. 1-Sep. 1, 1965

E. L. Anderson, B. B. Baker, and P. M. Ku Oct 1965 42 p (Contract AF 33(615)-2384)

(AFAPL-TR-65-118; AD-625485) CFSTI: HC \$2.00/MF \$0.50

Investigations were conducted to determine the possible effect of selected aircraft gas turbine engine lubricants and various solvents on the removal of carbonaceous deposits which had accumulated during service on the No. 2 bearing rear support of the J-57 engine. Six MIL-L-7808 type and one MIL-L-23699 type lubricants and six solvents were included in this program. Under the test procedures used, the deposits on the bearing support specimens were found to be quite stable in the presence of all seven lubricants investigated; no loosening or sloughing of the deposits was observed. Of the six solvents evaluated, only Cities Service 26

was found to be effective in removing significant amounts of deposits from the specimen. Flashing of liquid water, loosened crinkled, blistered, and flaked deposits but had no effect on smooth carbon or varnish. Author (TAB)

**N66-19762\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

**GALVANIC CORROSION OF ALUMINUM ASSEMBLIES BY STAINLESS STEEL WIRE INSERTS**

T. S. Humphries and E. E. Nelson 2 Mar. 1966 20 p (NASA-TM-X-53404) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

Data on the galvanic corrosion which is associated with bare and plated stainless steel inserts in aluminum assemblies are presented. Bare, cadmium plated, and silver plated stainless steel inserts which had been installed in 5456 and 2219 aluminum alloy blocks were tested in several corrosive environments—salt, brackish, and tap water and salt spray. It was found that the cadmium plated stainless steel inserts resulted in minimum galvanic corrosion of 5456 aluminum and afforded cathodic protection to 2219 aluminum. Silver plated stainless steel inserts that were tested caused severe galvanic corrosion of the aluminum assemblies and, therefore, are not recommended for use with aluminum. Author

**N66-19769#** Rock Island Arsenal Lab., Ill. Research and Engineering Div.

**RHEOLOGICAL PROPERTIES OF GREASES OVER WIDE TEMPERATURE RANGES** Technical Report

Robert L. Young Oct. 1965 33 p refs

(RIA-TR-65-2812; AD-625136) CFSTI: HC \$2.00/MF \$0.50

Routine physical characteristics were determined for ten lubricating greases of varying types. The roll stability test for lubricating grease, ASTM D1831-64, was performed on each grease at eleven temperatures ranging from -65° to 250°F and for extended periods of time. The apparent viscosity, ASTM D1092-62, was determined for each grease at the same temperatures. Curves were constructed from the roll stability, apparent viscosity and yield stress data. A departure from the general trend of the slope of these curves was taken as a possible phase change or transition temperature. The wear preventive characteristics of lubricating grease, ASTM D2266-64T were determined for two greases that gave indications of having definite phase changes. Wear tests were made over the working range of temperatures for each grease. The results did not show any noticeable change in lubricity of the grease occasioned by the indicated phase change. Author (TAB)

**N66-19772#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ANTIWEAR ADDITIVE FOR LUBRICATING OILS**

L. M. Kogan, A. M. Pavlovich, Yu. N. Bezobrazov, and N. M. Burmakina 21 Oct. 1965 6 p Transl. into ENGLISH from Russian Patent no. 166436 (Appl. no. 776560/23-5, 29 Apr. 1962) 2 p

(FTD-TT-65-795/1+2+4; AD-625053) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is the application of hexachlorocyclopentadiene as an antiwear additive to lubricating oils. Author (TAB)

**N66-19816#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**MOTOR AND JET OILS AND FLUIDS** Selected Chapters

K. K. Papok and Ye G. Semenidov 29 Dec. 1965 151 p refs Transl. into ENGLISH from the Book "Motornyye i Reaktivnyye Masla i Zhidkosti" Moscow, izd. "Khimiya", 1963 p 123-139, 224-236, 391-398, 411-462, 544-552, 673-691

(FTD-MT-64-382; AD-626977) CFSTI: HC \$5.00/MF \$1.00



Contents: Viscosity additives, Multifunctional additives, Diesel oils, Oils for turbojet and turboprop engines, Oils for gas turbines, Oils for rocket engines, Plastic lubricants and their structure, and Liquids for engine-cooling systems. TAB

**N66-20010#** Army Foreign Science and Technology Center, Washington, D. C.

**EFFECTS OF ADDITIVES ON ANTIWEAR AND ANTI-FRICTION PROPERTIES OF POLYSILOXANES**

M. I. Nosov and G. V. Vinogradov Dec. 1965 11 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 8, Aug. 1965 p 50-53

(FSTC-381-T65-553; AD-626078) CFSTI: HC \$1.00/MF \$0.50

The effect of some organic compounds containing sulfur, chlorine, and phosphorus on the lubricating action of polysiloxanes of various types under heavy friction loads were studied. Additives that show a high activity in preventing scoring of steel in hydrocarbon lubricating media were much less effective in polysiloxanes. Their activity decreased sharply on transition from polyethylsiloxane to polymethylsiloxane and then to polymethylphenylsiloxanes. They almost had no effect on the lubricating capacity of polymethylphenylsiloxanes. The assumption is made that the decomposition of well known additives, which determines their effectiveness in preventing scoring of steel, initiates chain reactions in which the principal components of lubricating oils participate. With increasing stability of lubricating media to reactions in which free radicals take part, the activity of additives that counteract scoring decreases. This explains the lack of effectiveness in polymethylphenylsiloxanes of the additives considered. Author (TAB)

**N66-20013#** Army Weapons Command, Rock Island, Ill. Research and Engineering Div.

**HIGH TEMPERATURE OXIDATION INHIBITION OF ALUMINUM COMPLEX SOAP GREASE**

Max T. Fisher Nov. 1965 23 p refs

(RIA-65-3264; AD-626582) CFSTI: HC \$1.00/MF \$0.50

The aluminum complex soap greases made previously (see AD-610 560) had good high and low temperature shear properties and good oxidation stability at 210° F but at 250° F were deficient in the latter property. Efforts to correct this deficiency consisted of incorporating antioxidants which had proved effective at the higher temperature in other grease types. The antioxidants were generally less effective at 250° F in these aluminum base greases than they were in other greases at the same temperature. Two of the inhibitors, 2,4'-diisopropyl amino diphenyl ether and a proprietary mixture of complex organic amines, did impart superior resistance to oxidation at 250° F. The former, in a one percent concentration, limited the pressure drop to 25 psi in 400 hours, and a 27 psi drop in 400 hours was recorded using the latter material in a 0.3 percent concentration. This work shows that it will be difficult to find antioxidants for limiting the pressure drop of aluminum complex soap grease to 20 psi in 400 hours at 250° F. Author (TAB)

**N66-20026#** Koninklijke Marine, The Hague (Netherlands). Verfcommissie.

**THE INFLUENCE OF PAINTS WITH A HIGH ZINC CONTENT ON THE WELDING OF A52 STEEL [DE INVLOED VAN ZINKRIJKE VERNEN OP DE LASBAARHEID VAN STAAL A 52]**

H. F. M. Frohn Sep. 1965 25 p In DUTCH

(AT-1959/69; TDCK-43691) CFSTI: HC \$1.00/MF \$0.50

Research was conducted to determine what effect corrosive-resistant paints with a high zinc content had on the welding of A52 steel. Also considered were such mechanical properties of welding bonds, as crack values, strength of V-shaped seam connection, cross welding connections, and fatigue strength. Results showed no adverse effects from ap-

plications of 15 to 18 microns of the protective paint. The influence of the spraying materials (steel bits and copper remnants) was also checked, with no major effects detected. Epoxy resin and chlorine rubber based paints are compared, and the recommendation is made that a primary coat of an epoxy resin paint with a high zinc content be applied during ship construction. Transl by J.O.

**N66-20193#** Lockheed Missiles and Space Co., Sunnyvale, Calif.

**HEAT TRANSFER FROM A CYLINDRICAL SURFACE WITH A DENSE NETWORK OF RIBS**

I. B. Tsesarskii [1965] 9 p refs Transl. into ENGLISH from Inzh. Fiz. Zh. (USSR), v. 9, no. 6, 1965 p 783-787

The heat transfer in lubricating oil from an intensely heated copper surface with a dense network of ribs was studied. The temperature field and the heat transmission coefficients from the heated surface to the cooling fluid were obtained by forming the differential equations for the heat propagation for the ribs and the heat balance for the fluid. The Laplace transform of these equations and their boundary conditions was then used to compute the heat transmission coefficients and to find an expression for the magnitude of the maximum heat transfer coefficient if the fluid temperature was constant over the whole channel section. G.G.

**N66-20254#** Mechanical Technology, Inc., Latham, N. Y. **AN EXPERIMENTAL STUDY OF FILM RUPTURE IN JOURNAL BEARINGS WITH LOW KINEMATIC VISCOSITY LUBRICANTS** May 1964-Feb. 1965

F. K. Orcutt and C. H. T. Pan Mar. 1965 63 p refs

(Contract AT(30-1)-3363)

(MTI-65TR13; NYO-3363-4) CFSTI: HC \$3.00/MF \$0.75

Studies of film rupture and cavitation in bearing film were extended to lubrication with fluids of low kinematic viscosity whose surface forces (surface tension and wettability) are different from those of hydrocarbon oils and closer to those of liquid metals. The study consisted of visual observations of the film rupture region, using high speed still and motion picture records. Local film boiling in the film rupture region was induced by de-aeration and reduction of ambient pressures. The visual studies and a parallel theoretical analysis indicated that the surface forces greatly affect the details of the film rupture region. Unstable film rupture regions as well as entrainment of bubbles and their carry-over to the high pressure regions of the lubricant film are much more prevalent when the lubricant has high surface tension and poor wettability. Since these conditions are at least a prerequisite to cavitation damage, it is particularly desirable in such cases to design bearings so as to avoid generation of large negative pressure gradients which can reduce the hydrodynamic pressures to the vapor pressure of the lubricant. Author (NSA)

**N66-20259#** Mechanical Technology, Inc., Latham, N. Y. **AN INVESTIGATION OF ROTOR-BEARING DYNAMICS WITH FLEXIBLE ROTORS AND TURBULENT-FLOW JOURNAL BEARINGS. PART 1: ANALYSIS, DESIGN AND FABRICATION OF THE TEST APPARATUS** Jun. 1964-Feb. 1965

F. K. Orcutt and E. B. Arwas Mar. 1965 76 p refs

(Contract AT(30-1)-3363)

(MTI-65TR12; NYO-3363-3) CFSTI: HC \$3.00/MF \$0.75

A description is given of the preliminary part of an investigation aimed at demonstrating feasibility and generating technology and design procedures on high speed rotors operating in the flexible rotor range while supported in pivoted pad journal bearings lubricated with a low viscosity liquid and operating in the turbulent flow regime. It is intended to operate three rotor arrangements over a speed range that, in each case, spans the first three system critical speeds and extends to above twice the first system critical speed. The rotor arrange-

case, spans the first three system critical speeds and extends to above twice the first system critical speed. The rotor arrangements are: (a) central mass between two journal bearings, (b) central mass between the two journal bearings plus an overhung mass on one end, and (c) central mass between the journal bearings plus overhung masses on both ends. The analysis, design, and fabrication of the test apparatus is described. The calculated critical speed maps as well as the calculated vibration amplitudes and phase angles of the response of the rotor bearings systems to unbalanced loads are presented.

NSA

**N66-20315#** Combustion Engineering, Inc., Windsor, Conn. Nuclear Div.

**INVESTIGATION OF CATALYTIC RECOMBINATION OF RADIOLYTIC OXYGEN AND HYDROGEN** Quarterly Report No. 5, Oct.-Dec. 1964

C. Thomas Sawyer and F. M. Stern 10 Jan. 1965 19 p ref (Contract AT(40-1)-3151)

(CEND-525, EURAEC-1330) CFSTI: HC \$1.00/MF \$0.50

The endurance testing of catalysts is accomplished by taking 835-900 psig power plant steam, superheating it to the desired temperature, adding metered hydrogen and oxygen, passing the steam over the catalysts and monitoring the effluent for the remaining free oxygen. For parallel arrangement tests, 60 lb/hr of steam was passed through each of the catalysts. Several conditions existed in the catalyst beds during the tests. Data are tabulated. Because the use of the catalytic recombiner was successful in inhibiting chloride stress corrosion, tests were made on the effects of oxygen on intergranular corrosion. For these tests, stressed and sensitized Type 304 stainless steel specimens were exposed to 800°F, 860 psig steam. Two weeks of testing produced no intergranular cracks or attack in specimens located either upstream or downstream of the catalyst bed. Fourteen days of operation at 800°F, 835 psig, and 775 lb/hr without any injected chlorides also produced no intergranular cracks or attack.

NSA

**N66-20408#** Societe d'Etudes, de Recherches et d'Application pour l'Industrie, Brussels (Belgium).

**CORROSION STUDIES ON STEELS IN WATER AND STEAM AT HIGH TEMPERATURE** Quarterly Progress Report No. 10, 1 Oct.-31 Dec. 1964

29 Jan. 1965 82 p refs Transl. into ENGLISH from French (EURATOM-089-62-7 RDB)

(EURAEC-1308) CFSTI: HC \$3.00/MF \$0.75

The static corrosion tests in superheated steam were continued for stainless steel type AISI 304, for the purpose of finding the type of oxidation obtained after sanding the surface of the test pieces. Silica sanding by compressed air has the same behavior as all the cold-worked states studied up to the present. In addition, the first tests in steam at 500°C, with the addition of oxygen, have been carried out. Subject to confirmation, the addition of a quantity of oxygen  $\leq 80$  ppm does not appear to greatly modify the behavior in superheated steam and, in particular, the advantage gained by surface work-hardening. Finally, it will be noted that a very light electrolytic polishing of milled test pieces (1 to 1.5  $\mu$  solution), does not change their behavior in superheated steam at 500°C whilst there is an extremely harmful effect in respect to corrosion in water at 300°C. Detailed metallographic examinations effected on different samples of 13-10 steel treated mechanically and then oxidized in steam at 500°C show that the presence of oxide precipitates in the metallic cold-worked area, under the continuous layer of oxides, is very probable. The dynamic corrosion tests in water at 300°C, 150 kg/cm<sup>2</sup>, and 10 m/sec, effected for varying periods up to 2,000 hours, have been completed. These tests show that the corrosion rate of 18-10 steel be-

comes very low above 1,000 hr of testing. Tests of extremely long duration would be necessary to define its value more accurately, which is between 0 and 5 mg/dm<sup>2</sup>/month. It is confirmed that the "surface state" factor has no appreciable influence on the rate of 10 m/sec. For boiler steel, it is verified that the "metal in water" component constitutes the principal corrosion element, which progresses linearly at a rate of approximately 500 mg/dm<sup>2</sup>/month. The adherent oxide skin on the test pieces is invariably 1  $\mu$ , whatever the duration of the test. The classification of the surface states remains that obtained during earlier static tests, the differences being greatly reduced, however. It is probable that the residual differences observed at the rate of 10 m/sec, are only apparent and attributable to the incidence of the surface treatment on the true surface of the test pieces. Author

**N66-20430#** Mechanical Technology, Inc., Latham, N. Y. **DESIGN AND DEVELOPMENT OF A GAS-BEARING BRAYTON CYCLE TURBOCOMPRESSOR**

1 Mar. 1965 96 p

(Contract AT(30-1)-3237)

(NYO-3237-1; MTI-64TR7) CFSTI: HC \$3.00/MF \$0.50

A technology program has been underway since June, 1962 to demonstrate feasibility of, and to identify problem areas associated with, the application of gas-lubricated bearings to closed-system gas-turbine machinery. A Brayton cycle gas generator (turbocompressor) utilizing self-acting gas bearings has been designed, built, and is now under test. Self-sustained closed-loop operation of the turbocompressor, using its own cycle gas as the bearing lubricant, was achieved on November 21, 1964. Design point conditions of the turbocompressor are: turbine inlet temperature=1300°F, compressor inlet temperature=100°F, compressor inlet pressure=15.5 psia, turbocompressor speed=24,000 rpm, cycle gas flow=-8,700 lb/hr nitrogen, and simulated power output=-30 kw. The aerodynamic, mechanical, and instrumentation aspects of the turbocompressor design and development program are described. A brief summary of the initial test-performance is also presented. Author (NSA)

**N66-20592#** Franklin Inst., Philadelphia, Pa. Research Labs. **EVALUATION OF FRICTION AND WEAR CHARACTERISTICS OF MATERIALS FOR GAS-LUBRICATED BEARINGS UNDER CONDITIONS OF START-STOP, AND WHIRL INDUCED RUBBING** Final Technical Report

J. G. Hinkle and D. D. Fuller Sep. 1965 94 p refs (Contract Nonr-4569(00))

(F-B2232; AD-625376) CFSTI: HC \$3.00/MF \$0.75

A materials evaluation study was made as applied to general types of self-acting gas-lubricated bearings under start-stop cycling with equal emphasis on ability to sustain whirl-induced solid contact. The study entailed a systematic program of investigation and classification of the performance in a realistic bearing environment of likely combinations of materials, surface treatments, and coatings at four ambient conditions: air at room temperature and atmospheric pressure, air at 300°F and atmospheric pressure, nitrogen at 300°F and atmospheric pressure. Concurrent with the above mentioned tasks, bearing instability characteristics (in contrast to journal instability) were studied experimentally and correlated with theory. Author (TAB)

**N66-20801#** Technisch Documentatie en Informatie Centrum Voor de Krijgsmacht, The Hague (Netherlands).

**LITERATURE SURVEY IN CHEMICAL TECHNOLOGY [LITERATUUROVERZICHT CHEMISCHE TECHNOLOGIE]**

9 Feb. 1966 37 p refs In DUTCH, GERMAN, and ENGLISH Its Vol. 1, No. CT-2

CFSTI: HC \$2.00/MF \$0.50

Abstracts and bibliographic notes are included on the topics of corrosion, surface treatment, plastics, lubricants, materials, water and air purification, fire fighting, packaging, batteries, chemicals, and technical news. Transl. by J.O.

**N66-21121#** Naval Research Lab., Washington, D. C.  
**A NEW APPROACH TO LUBRICATING BALL BEARINGS**  
 Interim Report

V. G. Fitz Simmons, C. M. Murphy, J. B. Romans, and C. R. Singleterry. 28 Dec. 1965. 25 p. refs.  
 (NRL-6356; AD-627345) CFSTI: HC \$1.00/MF \$0.50

A study was undertaken of the causes of unsatisfactory service and storage life of Navy synchros and servo motors. Silicone oils have been in wide use as the lubricant for the ball bearings of these devices because of the good low-temperature characteristics of these materials. Examination of bearings from synchros which failed qualification tests gave evidence of fretting corrosion, broken bearing retainers, dry residues, and loss of lubricant. A white flocculent substance was found in new silicone-lubricated bearings. This substance could be reproduced in the laboratory at room temperature when rubbing ferrous metals were lubricated with silicones. The principal cause of early synchro and servo motor bearing failure is believed to be the creeping away of the small supply of silicone lubricant from the load-carrying area of the bearings under service and storage conditions. Studies proved that a lubricant based on bis(2-ethylhexyl)azelate satisfactorily lubricated synchro bearings at temperatures as low as  $-55^{\circ}\text{C}$ . Creeping of lubricants composed either of the azelate ester or of silicones from ball bearings was prevented by the use of low-energy fluorochemical barrier films. The life of synchros containing bearings treated with the barrier film and lubricated with a bis(2-ethylhexyl)azelate composition has increased from 300 hours to nearly 4,000 hours on standard qualification tests. TAB

**N66-21312#** National Academy of Sciences—National Research Council, Washington, D. C. Materials Advisory Board.  
**METALWORKING PROCESSES AND EQUIPMENT** Third Progress Report by the Ad Hoc Committee

31 Oct. 1965. 32 p. refs.  
 (IMAB-206-M(3); AD-625049) CFSTI: HC \$2.00/MF \$0.50

An investigation was made of lubrication in metal working, application of deformation theory to practice, limitations of the extrusion processes, thin sheet rolling. TAB

**N66-21317#** Army Weapons Command, Rock Island, Ill. Research and Engineering Div.

**A NEW METHOD FOR THE ANALYSIS OF VOLATILE CORROSION INHIBITED PAPER**

Peter Martin, Jr. Nov. 1965. 25 p. refs.  
 (RIA-65-3105; AD-626584) CFSTI: HC \$1.00/MF \$0.50

The method utilized a commercial instrument, the Cor-rator, which measures instantaneous corrosion rates in a conducting media. Laboratory and field tests were conducted on new and used VCI paper to establish the reliability and accuracy of the method. The VCI papers were analyzed by adding a paper sample to the salt solution, stirring to remove the VCI, and noting the decrease in the corrosion rate. The decrease in the corrosion rate was converted to weight of loading (grams per square foot) by means of the standard curves previously prepared. The results obtained compared favorably with results obtained by other more tedious analytical methods. The method developed has the following advantages: utilizes a stable reagent, nontechnical personnel can conduct the test, the instrument is battery operated and the test time is less than one hour. TAB

**N66-21324#** Naval Research Lab., Washington, D. C.  
**PROTECTIVE COATINGS FOR MAGNESIUM ALLOYS.**  
**PART 2: RESISTANCE OF FLAME-FUSED TEFLON-COATED MAGNESIUM AND ALUMINUM ALLOYS TO CORROSION BY 3% SODIUM CHLORIDE SOLUTIONS**

D. L. Venezky, A. G. Sands, and E. B. Simmons, Jr. 15 Dec. 1965. 35 p. refs.

(NRL-6353; AD-626213) CFSTI: HC \$2.00/MF \$0.50

Teflon one-coat green enamel, which has been applied in thin films, 0.0002 to 0.0004 in. thick, and which has been properly flame fused, will not be wet by the 3% sodium chloride solution during the test period; specimens having such Teflon coatings exhibit enhanced corrosion resistance. Three methods were evaluated as accelerated corrosion tests: an immersion test, a salt droplet test, and a spherical-joint contact test which could be modified to measure the relative resistance of the coated specimens. Magnesium alloy AZ<sub>31</sub>B-H<sub>24</sub>, chrome pickled, was most resistant to corrosion when coated with flamefused Teflon one-coat green enamel; magnesium alloy specimens treated otherwise exhibited enhanced corrosion rates. Aluminum alloy 6061-T6, Teflon coated and flame fused, exhibited the greatest corrosion resistance when compared with the other aluminum alloys tested. No correlation was found between the various aluminum alloy tempers studied and the corrosion rate. In general, the corrosion tests indicate that the flame-fused Teflon coating afforded some protection against corrosion as compared to the uncoated specimens. TAB

**N66-21419#** Rock Island Arsenal Lab., Ill. Research and Engineering Div.

**DEVELOPMENT OF AN IMPROVED RINSE SOLUTION FOR PHOSPHATE COATINGS THROUGH ADDITION OF ORGANIC ACIDS**

William O. Crawford. Jan. 1966. 25 p. refs.  
 (RIA-66-67; AD-628072) CFSTI: HC \$1.00/MF \$0.50

Work was undertaken in order to improve the salt spray resistance capabilities of phosphate coatings through innovations in the post treatment of the phosphate coatings and specifically through improvements in the supplementary rinse solutions. Various compounds, both organic and inorganic, were tested in solution, both by themselves and in combination with each other and with the existing chromic acid rinse solution, as possible rinses for phosphate coatings. It was found that four different 1-4 and 1-5 dicarboxylic acids, when used in the proper concentration with the existing 0.6 gm/liter (0.08 oz./gal) chromic acid rinse increased the salt spray life of a phosphate coating by at least one hour over the salt spray life of a coating treated in the standard 0.6 gm/l chromic acid rinse. These four acids are: citric acid, glutaric acid, maleic acid and succinic acid. It was also found that one aromatic dicarboxylic acid tested, phthalic acid, had the same effect on the salt spray life as the above mentioned aliphatic acids. Author (TAB)

**N66-21473#** Rock Island Arsenal Lab., Ill. Research and Engineering Div.

**FACTORS INFLUENCING CORROSION PROTECTION PROVIDED BY SOLID FILM LUBRICANT COATINGS**  
 Final Technical Report

George P. Murphy and Francis S. Meade. Dec. 1965. 25 p. refs.  
 (RIA-65-3380; AD-627395) CFSTI: HC \$1.00/MF \$0.50

This investigation included the effect of (1) resin-pigment ratio, (2) coating thickness, and (3) wearing away of the film on the corrosion protection provided by solid lubricant coatings. Two series of solid film lubricants of various resin-pigment ratios were made using good and poor pigment dispersion techniques. These series of solid film lubricants

were evaluated at several levels of coating thickness. Corrosion protection was evaluated by means of 20% Salt Fog cabinet while wear life was determined by the Falex Wear Test method. A combination friction-salt fog test was used in determining the effect of wearing away of the film on corrosion resistance. It was found that a solid film lubricant can be manufactured, using good pigment dispersion techniques, which will provide 1000 hours of salt fog protection. This lubricant showed no loss in wear life. It was also found that, by using a 0.0010 in. coating made up of two layers, salt fog life can be increased by at least 6 fold without sacrificing wear life. Author (TAB)

**N66-21481#** Ampex Corp., Redwood City, Calif.  
**SELF-ACTING FOIL BEARINGS OF INFINITE WIDTH**  
 Edward J. Barlow Jan. 1966 25 p refs  
 (Contract Nonr-3815(00) (X))  
 (RR-65-14; AD-628021) CFSTI: HC \$1.00/MF \$0.50

The minimum gap between a rigid cylinder and a moving foil (or between a rotating cylinder and a stationary foil) is determined as a function of the wrap angle as well as of the foil speed and tension, the cylinder radius, and the viscosity of the lubricant. Author (TAB)

**N66-21940#** Laboratoires du Centre d'Etude de l'Energie Nucleaire, Mol (Belgium).  
**IN PILE CORROSION OF NUCLEAR MATERIALS Final Report, Mar. 1962-31 Mar. 1964**  
 [1964] 43 p  
 (Contract EURATOM-084-62-3 RDB)  
 (EUR-2674; EURAEC-1522) CFSTI: HC \$2.00/MF \$0.50

Corrosion experiments on aluminum, stainless steel, zirconium, titanium, niobium, zircaloy-2 and platinum were carried out in-pile and after pile irradiation, and the results were compared with those obtained out-of-pile under identical conditions. Two horizontal channels and one vertical channel of the BR1 reactor were used in which the thermal neutron flux was  $1.38 \times 10^{12}$  n/cm<sup>2</sup>/sec and the fast neutron flux was  $1.4 \times 10^{12}$  n/cm<sup>2</sup>/sec (2.8 Mev). The gamma flux during operation of the reactor was  $7.3 \times 10^5$  R/hr for energies between 1 and 5 Mev. After shut-down the gamma flux was  $2.6 \times 10^5$  R/hr for energies from 0.4 to 2.8 Mev. Electrochemical techniques were applied as testing method. It was confirmed that passivation of aluminum is improved by pile irradiation, as indicated by decreased anodic currents and increased oxygen overvoltages. Potential-current curves on 18/8 chrome nickel steels showed that the anodic currents increased with irradiation when the solution was nitrogen, oxygen, or argon saturated and in all acidities. In-pile potential-current measurements on a ferritic steel (CSX) showed large anodic currents and current peaks. These electric currents indicated a strong general corrosion. The post irradiation examination of zirconium, Zircaloy-2, titanium, and niobium showed that the thickness of the initial oxide films on those metals increased with increasing irradiation dose. Gamma rays had a similar, but smaller effect as pile irradiation. It was concluded that the effects of pile irradiation on the corrosion process are mainly solution effects and not so much metal effects. However, the mechanism of the reactions is not well understood. (NSA)

**N66-22066#** Sandia Corp., Albuquerque, N. Mex.  
**WEAR TESTING OF PLATED COATINGS**  
 C. W. Jennings Jul. 1965 32 p refs  
 (Contract AT(29-1)-789)  
 (SC-DR-65-269) CFSTI: HC \$2.00/MF \$0.50

An investigation was conducted to determine the wear characteristics of combinations of electroplated metals for use in rotary switches. From specimens electroplated under con-

trolled conditions and tested for wear resistance with a wear tester which was similar in operation to a rotary switch, no apparent correlation was found between wear resistance and conditions of electroplating, other than thickness of the deposits. A thin film of soft gold (approximately 30 millionths of an inch thick) electroplated on a hard substrate of rhodium or electroless nickel or bright nickel was found to provide better wear characteristics than a rhodium-on-nickel system. A few tests were also run on gold alloy boards and ion-plated gold on alumina substrates. The latter combination, which had excellent wear characteristics, shows considerable promise for high temperature or corrosive applications. Author (NSA)

**N66-22187#** Metallgesellschaft, A. G., Frankfurt am Main (West Germany).  
**FURTHER DEVELOPMENT OF THE ZIRCONIUM ALLOY ZrNb3Sn1 WITH A VIEW TO ITS APPLICATION AS JACKETING MATERIAL IN WATER-COOLED NUCLEAR REACTORS Quarterly Report No. 3, 1 Apr.-30 Jun. 1964**  
 7 Jul. 1964 16 p refs Transl. into ENGLISH from German (Contract EURATOM-019-63-11 TEED)  
 (EURAEC-1115)

ZrNb3Sn1 alloys with small admixtures of chromium, iron, germanium, copper, antimony, tellurium and vanadium were examined in comparative corrosion experiments in superheated steam at 400° and 450°C. After 1000 hours in superheated steam at 450°C, the following alloys show a considerably lower corrosion than the ZrNb3Sn1 alloy: (1) ZrNb 2.78 Fe 0.1, (2) ZrNb 2.78 Sn 0.3 Fe 0.1, (3) ZrNb 2.78 Sn 1 Fe 0.1, (4) ZrNb 1.90 Sn 1 Fe 0.5, (5) ZrNb 2.34 Cu 0.2, (6) ZrNb 2.34 Sn 0.6 Cu 0.2, (7) ZrNb 1.74 Cr 0.5, (8) ZrNb 2.56 V 0.1-Sn 0.3, (9) ZrNb 2.04 Sb 0.2, (10) ZrNb 2.04 Sb 0.2-Sn 0.3. Large cast ingots were smelted from these alloys and prepared as test material for more thorough corrosion experiments and for mechanical examination. Creep test experiments at 450°C, and tensile tests at room temperature and 450°C were started. The stress in the creep tests amounted to 3 and 4.5 kg/mm<sup>2</sup> respectively. Author

**N66-22205#** Oak Ridge National Lab., Tenn.  
**SNAP-8 CORROSION PROGRAM Quarterly Progress Report, Period Ending 31 May 1965**  
 H. W. Savage, E. L. Compere, R. E. Mac Pherson, W. R. Huntley, and A. Taboada Sep. 1965 20 p refs  
 (NASA Order C-220-A; Contract W-7405-ENG-26)  
 (NASA-CR-67272; ORNL-3859) CFSTI: HC \$1.00/MF \$0.50 CSCL 18N

Corrosion loops for the SNAP-8 system were studied to determine differences in corrosion and mass transfer rates resulting from continuous cold trapping, and to evaluate the effectiveness of cold trapping in reducing the hydrogen concentration in the NaK loop. Extraneous hydrogen was observed with both an on-stream mass spectrometer and gas sampling techniques, however the rate of extraneous hydrogen diminished with time. Deuterium was introduced into the loop to distinguish between extraneous hydrogen and that injected into the loop. Data indicated that the equilibrium pressure in the loop is approximately the same as the calculated hydrogen partial pressure for the SNAP-8 primary system in space. A study was made to determine the effects of decarburization on selected mechanical properties of Croloy 9M. Sheet tensile specimens were decarburized to a carbon content of approximately 0.002 to 0.01%, by exposure to

**N66-22327\*** General Electric Co., Cincinnati, Ohio. Missile and Space Div.

**ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM** Quarterly Progress Report No. 3, Period Ending Jan. 15, 1966

R. W. Harrison, ed. 3 Feb. 1966 33 p refs

(Contract NAS3-6474)

(NASA-CR-54911) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

Work progress for a program to fabricate, operate for 10,000 hrs. and evaluate a potassium corrosion test loop constructed of T-111 (Ta-8W-2Hf) alloy is reported. The program status for procurement of materials; purification and handling of alkali metals; quality assurance; and loop design are given. All of the lithium purification system drawing revisions were completed. Assembly of the argon-vacuum manifold for the lithium purification system was begun, and a hot trap was fabricated. Minor design changes were made and specifications for the T-11 Corrosion Loop I are being written. L.S.

**N66-22627\*** Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.

**IMPROVED ELECTRON FRACTOGRAPHIC TECHNIQUES, VOLUME II** Second Quarterly Progress Report, 1 Oct.-31 Dec. 1965

B. V. Whiteson, V. Kerlins, and A. Phillips 14 Jan. 1966 38 p

(Contract AF 33(615)-3014)

(SM-49150; AD-626774) CFSTI: HC \$2.00/MF \$0.50

Improved techniques for use of the electron microscope in fractographic analysis are sought. The program is divided into 3 tasks: Determination of the direction of rapid-crack propagation in metal fractures; determination of the characteristics distinguishing stress corrosion from hydrogen embrittlement; and investigation of the correlation between fatigue striation spacing and stress environment. Most of the mechanical tests for the 3 tasks were completed. The most promising technique for correlation of fracture features with direction of crack propagation was replication of the fracture surface adjacent to the edge. Consistent orientation appears between tear dimple (a dimple open to the edge) and the fracture direction near the edge. Shear dimples which are closed to the fracture edge have inconsistent correlation to fracture direction. Dimples located near the center of the fracture are either equiaxed or randomly oriented so that they show no apparent correlation to fracture direction TAB

**N66-22684\*** Army Foreign Science and Technology Center, Washington, D. C.

**CORROSION PROTECTION AND CLEANING OF TANKS AND CONTAINERS**

I. V. Rozhkov Dec. 1965 122 p refs Transl. into ENGLISH of the book "Zaschita ot Korrozii i Zachistka Reservuarov i Tary" Moscow, 1963

(FSTC-381-T65-673; AD-627701) CFSTI: HC \$4.00/MF \$0.75

The book examines the new method of preservation of tanks and containers, based on the use of corrosion inhibitors, and its advantages over the old method of preservation of technical stock with oils and greases. A new technology is adduced for washing and preserving drums, tanks, and pipes, which increases 3-4 times the storage time of the preserved stock and decreases several times the cost of these operations. The book also examines briefly the paint-varnish coatings intended for protection of tanks and containers from corrosion. There is a detailed description of modern mechanized methods of cleaning tanks and tankers of residues of petroleum products, dirt, and rust, which decrease several times

the idle time of tanks and tankers during cleaning operations. An examination is made of the economy of the new cleaning methods in comparison with the old methods based on manual labor. This textbook is intended for officers and men, as well as for workers engaged in the operation of fuel tank yards and bases, and the tanker fleet. It will be useful also to the workers of plants manufacturing technical stock for the fuel supply service. Author (TAB)

**N66-22717\*** Mechanical Technology, Inc., Latham, N. Y. **CONDITIONS FOR THE RUPTURE OF A LUBRICATING FILM**

J. C. Coyne and H. G. Elrod, Jr. Dec. 1965 57 p refs

(Contract Nonr-3731(00))

(MTI-65TR58; AD-629039) CFSTI: HC \$3.00/MF \$0.50

An analysis is made to determine the shape of the film-vapor interface when a thin liquid film separates from a stationary surface and is swept away on an opposing moving surface. Situations in which variations of this phenomenon occur include cavitation in bearings, the spreading of thin films, and the movement of bubbles in narrow spaces. The results of the analysis show that for a fixed attachment height the flow carried in the separating film decreases with decreasing  $N = (3\mu U/T)^{1/3}$ . Stagnation points occur on the interface (with upstream recirculation) at a film height of  $3F/U$  where  $F$  is the flow per unit film width and  $U$  is the plate velocity. As  $N$  decreases, the flow decreases; and the stagnation point moves down the interface toward the moving plate. A second stagnation point always occurs at the point of film attachment. A second important result is that film separation occurs in a distance of about one plate clearance. Because this transition distance is very small, the analysis is applicable to situations in which the plate velocity is not normal to the film edge, e.g., striated cavitation in bearings. The upstream transition distance is shown to be a few plate clearances. TAB

**N66-22759\*** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PLASTICS Selected Articles**

30 Sep. 1965 17 p refs Transl. into ENGLISH from Plastikskkiye Massy (Moscow), no. 9, 1964 p 18-20; 41-43

(FTD-TT-65-909/1+2+4; AD-622355) CFSTI: HC \$1.00/MF \$0.50

**CONTENTS:**

1. SELECTION AND APPLICATION OF SILICONE FLUIDS TO DECREASE THE ADHESION OF PLASTICS TO SOLID SURFACES L. M. Vinogradova, A. Ya. Korolev, P. V. Davydov, and R. V. Kuchenkova p 1-7 refs (See N66-22760 12-18)

2. THE EFFECT OF LOW TEMPERATURES ON THE ANTIFRICTION PROPERTIES OF POLYCAPROLACTAM Yu. A. Yevdokimov, A. F. Kotenko, and M. S. Popov p 8-13 refs (See N66-22761 12-18)

**N66-22761** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE EFFECT OF LOW TEMPERATURES ON THE ANTIFRICTION PROPERTIES OF POLYCAPROLACTAM**

Yu. A. Yevdokimov, A. F. Kotenko, and M. S. Popov In its Plastics 30 Sep. 1965 p 8-13 refs (See N66-22759 12-18)

CFSTI: HC \$1.00/MF \$0.50

The antifriction properties of polyamides (polycaprolactams) at low temperatures were investigated. The wear and coefficient of friction of both capron and bronze on steel with and without lubrication, were determined: (1) at 20° to 25°C, without preliminary cooling of the samples, (2) at 20° to 25°C, with preliminary cooling of the samples at -50°C

for 10 and 20 days, and (3) at  $-50^{\circ}\text{C}$ . Tests were conducted at a constant specific pressure of  $30\text{ kg/cm}^2$  and at different slip speeds of 0.25, 0.5, 0.99 and  $1.95\text{ m/sec}$ ; and at a constant slip speed and different specific pressures of 10, 30, 50, and  $75\text{ kg/cm}^2$ . The tests were conducted on a lathe, and experimental details are described. Graphs are depicted, showing the dependence of both volume wear and friction coefficients for both capron and bronze during friction against a steel disc (from the lathe) at the varying slip speeds and pressures. The results are discussed. L.S.

**N66-22765#** Naval Research Lab., Washington, D. C.  
**A SYSTEMATIC APPROACH TO THE BEHAVIOR OF METAL SOAP-OIL SYSTEMS**

R. N. Bolster and R. C. Little 6 Jan. 1966 15 p refs  
 (NRL-6361; AD-627856) CFSTI: HC \$1.00/MF \$0.50

Application of the solubility parameter concept to micellar and crystalline metal soap dispersions in low-polarity solvents can give some order to effects of the solvent in these systems. The ASTM dropping point temperature is shown to be a function of solubility parameter, and it is proposed that dropping points can be estimated when solubility parameters are known. A new method for estimating the solubility parameter of an oil, based on its interaction with soap, is also suggested. Author (TAB)

**N66-22779#** Naval Research Lab., Washington, D. C.  
**ANALYSIS FOR ACYL COMPONENTS OF NEOPENTYL POLYOL ESTER LUBRICANTS Interim Report**

J. G. O'Rear and P. J. Sniegowski 5 Jan. 1966 10 p refs  
 (NRL-6338; AD-628914) CFSTI: HC \$1.00/MF \$0.50

Methods of gas chromatography were applied to the analysis of acyl components in commercial neopentyl esters and in lubricant formulations derived from such esters. Analysis of the free acids produced by hydrolysis of the samples revealed that the ester lubricants were derived from normal acids ranging from  $\text{C}_5$  to  $\text{C}_{10}$ ; isovaleric acid was present in a few samples. Average acid chain length varied from 5.1 to 7.5. From 20 to 83% of the acyl groups found in the lubricant formulations were from n-valeric acid. All results were in good agreement with previous results obtained by nuclear magnetic resonance spectroscopy. Author (TAB)

**N66-23233#** Oak Ridge National Lab., Tenn. Chemistry Div.  
**AN ALL-METAL CELL TECHNIQUE FOR THE MEASUREMENT OF THE EMF OF MOLTEM METAL-METAL HALIDE SOLUTIONS CORROSIVE TO CERAMICS**

Harry R. Bronstein [1964] 3 p Presented at the Electrochemical Soc. Meeting, San Francisco  
 (Contract W-7405-ENG-26)

(ORNL-P-814; CONF-650502-3) CFSTI: HC \$1.00/MF \$0.50

The need for an all-metal cell technique for corrosive rare earth-rare earth halide solutions is pointed out. Such a technique, using Ta metal tubes with sintered porous Ta plugs welded in the sides, was applied to the  $\text{Hg(s)}$ ,  $\text{HgSO}_4$  (saturated solution)/ $\text{Ag(s)}$ ,  $\text{Ag}_2\text{SO}_4$  (saturated solution) cell. The potential was determined to be  $+41.5 \pm 0.1\text{ mV}$  at  $25^{\circ}\text{C}$ , in good agreement with previous values. The technique was also applied to the molten  $\text{Cd-CdCl}_2$  system at  $635^{\circ}\text{C}$ . For 2 and 10 mole %  $\text{Cd-CdCl}_2$  electrodes vs the saturated  $\text{Cd-CdCl}_2$  electrode, the potentials were  $+111.0$  and  $+33.0\text{ mV}$ , respectively, in good agreement with values ( $+113$  and  $+35\text{ mV}$ ) obtained in an all-glass apparatus. NSA

**N66-23371#** Brookhaven National Lab., Upton, N. Y.  
**HIGH-TEMPERATURE LIQUID-METAL TECHNOLOGY REVIEW Bimonthly Technical Progress Review, Volume 3, No. 4, Aug. 1965**

Nov. 1965 52 p  
 (Contract AT(30-2)-GEN-16)

(BNL-953(PR-16)) CFSTI: HC \$3.00/MF \$0.50

Twenty-one reviews of current topical and progress reports on research and development programs concerned with liquid metals are presented. Subjects covered include: fluid dynamics, heat transfer, material development, corrosion, instrumentation, chemistry, chemical analysis, and component development. NSA

**N66-23394#** Office of Naval Intelligence, Washington, D. C.  
 Translation Section.

**PROTECTION OF STEEL AND LIGHT ALLOYS WITH POLYVINYL BUTYRAL PHOSPHATIZING PRIMERS VL-023 [ZASHCHITA STALI I LEGKIKH SPLAVOV POLIVINIL-BUTIRAL'NYMI FOSFATIRUYUSHCHIMI GRUNTAMI VL-023]**

G. Ya. Terlo [1966] 8 p Transl. into ENGLISH from Lakokrasochnyye Materialy i ikh Primeniye (Leningrad), no. 5, 1964 p 33-36

(ONI-TRANS-2060; TT-66-60554; AD-628185) CFSTI: HC \$1.00/MF \$0.50

It is shown that the newly developed phosphatized primers VL-023 based on medium-viscous polyvinylbutyral and modified phenol resins have high stability, water and atmosphere resistance, excellent covering capability and dispersion. It is also shown that the primers VL-023 can be used for protection of metal against atmospheric corrosion during the period of inter-operational preservation (replacing phosphatized salt 'mazhef' and oiling). Author (TAB)

**N66-23581#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**EFFECT OF OIL OXIDATION ON THE PROCESS OF RUNNING-IN A RING-SOCKET PAIR IN AN INTERNAL COMBUSTION ENGINE**

S. V. Ventsel', M. M. Chupis, and V. O. Lelyuk 26 Nov. 1965 11 p refs Transl. into ENGLISH from Dopovidi Akad. Nauk Ukr. RSR. (Kiev), no. 4, 1964 p 499-501

(FDT-TT-65-1039/1+2+4; AD-624910) CFSTI: HC \$1.00/MF \$0.50

A typical scheme of the running-in process was obtained on an experimental set-up simulating the work of a ring in a socket. It was found that stabilization of the temperature and the work of friction does not characterize the end of the running-in process, but the formation in the oil of oxidation processes and oxidative polymerization. The phenomenon of 'apparent' repeated running-in was observed on replacing the worked oil by fresh oil. The results furnish grounds for revising plant conditions of running-in. Author (TAB)

**N66-23647\*#** Southern Research Inst., Birmingham, Ala.  
**EFFECTS OF COMMERCIALLY AVAILABLE PROTECTIVE COATINGS ON STRESS-CORROSION PROPERTIES OF SUPERSONIC-TRANSPORT SKIN MATERIALS Final Summary Report, 1 Jun. 1964-31 Jan. 1966**

J. O. Honeycutt, Jr. and A. Clyde Wilhelm 22 Mar. 1966 143 p refs  
 (Contract NASr-117)

(NASA-CR-74414) CFSTI: HC \$4.00/MF \$1.00 CSCL 11F

The experiments consisted of the exposure of self-stressed specimens, bare and coated, scratch damaged and undamaged, to environments of hot salt at  $550^{\circ}\text{F}$  and humid salt at  $95^{\circ}\text{F}$  for durations up to 7,000 hr. The substrates investigated were titanium alloy Ti-8-1-1 (titanium with 8% aluminum, 1% molybdenum, 1% vanadium), AM 350 SCT (a high-strength stainless steel in the sub-zero-cooled and

tempered condition), and Rene 41 (a nickel-base super-alloy in the heat-treated and aged condition). The coatings investigated on all three substrates were designated as aluminum-modified silicone, catalytically cured silicone, and zinc in silicate vehicle. The effects of the exposures were evaluated by means of visual examination, bend-ductility tests, and metallographic examination. In addition to the experimental work, survey was made of five airframe manufacturers to determine their latest opinions about SST coatings. The experimental results were interpreted with respect to the findings from this survey. A preliminary evaluation was made on five additional coatings that had not been included in this or the previous investigations. Author

**N66-23655\***# Aluminum Co. of America, New Kensington, Pa. Alcoa Research Labs.

**INVESTIGATION OF THE STRESS-CORROSION CRACKING OF HIGH STRENGTH ALUMINUM ALLOYS Summary Report, May 6, 1963-Jul. 6, 1965**

B. W. Lifka, W. King, M. B. Shumaker, R. A. Kelsey, and D. G. Vandenberg. 1 Aug. 1965 181 p refs  
(Contract NAS8-5340)

(NASA-CR-74443) CFSTI: HC \$5.00/MF \$1.25 CSCL 11F

Stress corrosion cracking of several high-strength aluminum alloys was tested in various environments, after protective surface treatments and coatings, and after tempering and welding. Parent Al-Zn-Mg alloys were little affected; but in the as-welded condition, all investigated Al alloys suffered severe localized corrosions of the heat affected zones. Post-weld aging eliminated this effect greatly. Good stress-corrosion cracking resistance was obtained for all alloys when they were welded and stressed either in bending, or in tensions as high as 75% of their weldment strength. Post-weld aging decreased weld-strength to corrosion cracking markedly. Plate to forging combinations of alloys with different grain orientations showed the same resistance to stress-corrosion cracking as the plate. Direct tension loading caused more rapid failure of susceptible materials than bending on constant deformation fixtures; but severely corroded specimens showed long time failure modes. G.G.

**N66-23670\***# SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**BEARING-LUBRICANT ENDURANCE CHARACTERISTICS AT HIGH SPEEDS AND HIGH TEMPERATURES Final Report, 1 Sep. 1962-31 Aug. 1965**

C. J. Wachendorfer and L. B. Sibley [1965] 128 p refs  
(Contract NASw-492)

(NASA-CR-74097; AL65T068) CFSTI: HC \$4.00/MF \$1.00 CSCL 13I

This study was performed to determine operability, critical mode of failure and life of angular-contact ball bearings of advanced design at high temperatures in excess of 500°F using the best available fluid lubricants in a recirculating system. Ball bearings made of vacuum-melted tool steels having high hot hardness were tested with a number of high-temperature fluid lubricants representing hydrocarbons, esters, and polyphenyl ethers. The results indicate that satisfactory operation is possible at bearing temperatures at least up to 600°F. Ten bearings made of M-1 tool steel with silver-plated cages and tested with a lubricant containing a synthetic paraffinic hydrocarbon with an anti-wear additive, ran at 600°F and 42,800 rpm without any sign of failure or lubrication distress to lives in excess of twice the computed  $L_{10}$  life. A broad correlation was obtained between the occurrence of surface distress and low lubricant viscosity at the bearing operating temperature. This is believed to reflect an insuffi-

cient elastohydrodynamic lubricant film condition in the bearing. Insufficient boundary lubricant characteristics of some fluids were found to produce smearing (galling) type failures early in the tests. Author

**N66-23825\***# National Academy of Sciences—National Research Council, Washington, D. C. Div. of Chemistry and Chemical Technology.

**[INFORMATION SERVICES RELATING TO THE PREVENTION OR LIMITATION OF ENVIRONMENT-ASSOCIATED DEGRADATION OF MATERIALS AND EQUIPMENT] Final Report**

Jan. 1966 14 p

(Contract NASr-182)

(NASA-CR-71680) CFSTI: HC \$1.00/MF \$0.50 CSCL 11I

Information services relating to the prevention or limitation of environment-associated degradation of materials and equipment were provided to the National Aeronautics and Space Administration. The contract provided partial support for the Prevention of Deterioration Center, an information center in this field of environmental and materials sciences, established and continued with primary support under a contract funded by the Army, Navy, and Air Force. The services provided to NASA included consultations on specific deterioration problems, abstracts of scientific and technical documents, bibliographies, document loans from the Prevention of Deterioration Center library and a state-of-the-art monograph related to the meteoroid environment. Another product of contract is a glossary of terms used in materials degradation studies in the hyperthermal environment. Author

**N66-24253#** Joint Publications Research Service, Washington, D.C.

**RESISTANCE OF EP375 AND EP495 ALLOYS TO DEFORMATION**

B. A. Kardonov, A. F. Mel'nikov, A. V. Pravdin, and A. S. Tikhonov. In *its* Production of Bimetals. 30 Mar. 1966 p 79-84 refs (See N66-24246 13-17) CFSTI: \$6.00

High strength and anti-corrosion steel alloys from the nickel-chromium-molybdenum, and from the nickel-molybdenum base were evaluated for their applicability as clads in the production of bimetallic sheets by the pack method. Nickel-molybdenum based alloys displayed a 5 to 7 per cent greater resistance to hot deformation temperatures than the nickel-chromium-molybdenum based group. Temperatures below 1000°C led to structural transformation of the alloys. Rolling in the 900° to 1200°C temperature range increased deformation resistance of the alloys by 25 to 30 percent. G.G.

**N66-24265#** Joint Publications Research Service, Washington, D. C.

**NEW STANDARD FOR HOT ROLLED THICK TWO-LAYERED CORROSION RESISTANT STEEL**

T. K. Aleksandrova, I. A. Balakina, and A. M. Kanunnikova. In *its* Production of Bimetals. 30 Mar. 1966 p 197-205 refs (See N66-24246 13-17) CFSTI: \$6.00

Bimetallic sheet specimens, having a steel base layer and steel cladding, were manufactured by the pack-cladding method according to standard procedures for hot rolling. Safe layer criteria and corrosion stability were utilized to establish minimum thickness specifications for the cladding layer. Base thickness and clad layer ratios determined overall strength properties; plasticity of the base layer was checked by the flexure method with the base layer outward. It was concluded that resistance to shear did not depend on the brand of steel of the base layer, and that shear resistance along the border of the layer connections was somewhat higher than

shear resistance along the base metal. A list with the obtained standard specifications for hot-rolled thick two-layered corrosion resistant bimetal steel sheets was tabulated. G.G.

**N66-24268#** General Electric Co., San Jose, Calif. Atomic Products Div.

**GENERAL ELECTRIC SODIUM MASS TRANSFER PROGRAM**

R. S. Young and R. W. Lockhart /in AEC Proc. of Sodium Components Develop. Program Inform. Meeting, Chicago, Ill., Jun. 16-17, 1965 [1965] p 18-35 refs (See N66-24266 13-22) CFSTI: HC \$3.00/MF \$1.50

This report describes the status of a study being conducted on mass transfer and corrosion of materials in flowing sodium. The study is involved in evaluating the use of candidate materials in sodium cooled reactors in non-nuclear loop tests, and in developing a means of predicting corrosion or mass transfer rates in full sized systems. Included are discussions of the mass transfer results, localized corrosion effects, and corrosion mock-ups for large sodium systems. R.N.A.

**N66-24419#** General Electric Co., San Jose, Calif.  
**SPECIFIC ZIRCONIUM ALLOY DESIGN PROGRAM Summary Report**

H. H. Klepfer Brussels, EURATOM, 1966 99 p refs  
(Contract AT (04-3)-189)  
(EURATOM-2683.e; EURAEC-1193) CFSTI: HC \$3.00/MF \$0.75

The results of selected basic experiments gave strong indications that the corrosion and corrosion hydriding of zirconium alloys is dependent on the chemical, mechanical, and electrical properties of the oxide film. The composition of corrosion films was found to be directly proportional to the alloy content of the substrate even in complex alloys. Excellent agreement was found between the activation energy for oxygen diffusion in  $ZrO_{1.994}$  and the activation energies for parabolic or cubic oxidation of zirconium in both air and water. Yttrium decreased the plasticity of zirconium oxide while chromium and iron increased plasticity, and thus accounted for the early spalling of oxide observed for Zr-Y alloys and the good adherence of films on Zr-Cr and Zr-Fe alloys. Corrosion hydriding may be controlled by whether electronic, or protonic, charge transport is promoted by the addition of a given alloying element to the zirconium oxide film. Corrosion rates, hydriding rates, and mechanical properties of 31 alloys containing selected additions of Nb, Cr, Fe, or Cu were measured at 300, 400, and 500°C. Author

**N66-24442\*#** Aerojet-General Corp., Azusa, Calif. Von Karman Center.

**SNAP-8 MATERIALS REPORT Semiannual Report, 1 Jan.-30 Jun. 1965**

H. Derow and B. E. Farwell Jul. 1965 89 p refs /ts Rept.-3038

(Contract NAS5-417)  
(NASA-CR-54719) CFSTI: HC \$3.00/MF \$0.75 CSCL 18N

Investigations were conducted in support of the design, fabrication, and development testing of various SNAP-8 components. Investigation of a mercury forced-convection corrosion loop was continued with the aim of evaluating the corrosion resistance of 9Cr-1Mo alloy steel (the reference mercury-containment material) for 10,000-hour service. Rubidium is being evaluated as an additive to the mercury to promote boiler conditioning. Data were developed in a continued program to evaluate the effect of the SNAP-8 operating environment on 9Cr-1Mo steel. Author

**N66-24451#** Atomic Energy of Canada, Ltd., Chalk River, (Ontario).

**AECL EXPERIMENTS ON THE CORROSION OF ZIRCONIUM ALLOYS UNDER IRRADIATION**

B. Cox May 1965 82 p refs  
(AECL-2257) CFSTI: HC \$1.50/MF \$0.75

The corrosion of zirconium alloys under irradiation has been examined at AECL by exposing corrosion specimens in the water-cooled loops in NRX and NRU reactors. The results of these experiments are reported here and are compared with evidence obtained from the examination of fuel cladding in the same experiments where this is available. The data on Zircaloy-2, the alloy for which most information is available, are compared with the results of experiments elsewhere, and it is concluded that the observations of oxidation and oxygen absorption are influenced considerably by conditions in the specimen's environment. Thus, 'oxidizing' conditions in the loop coolant have often been accompanied by increased weight gains and reduced hydrogen uptake. Under 'reducing' conditions the observed oxide film thickness is normal. Author

**N66-24474#** National Academy of Sciences—National Research Council, Washington, D. C.

**FINAL REPORT OF THE PANEL ON LUBRICATION TO THE AD HOC COMMITTEE ON METALWORKING PROCESSES AND EQUIPMENT**

Sep. 1965 41 p refs  
(Contract ARPA SD-118)  
(MAB-220-M)

The state-of-the-art of knowledge in friction and lubrication as they relate to deformation processes and equipment utilization in metal working, was surveyed. Proper selection of a lubricant has to consider individual requirements of low friction and low wear characteristics for specific forming conditions; lubricants also control the temperature of a work piece or die in the deformation process. Equations, based on the law of adhesion, were used to determine the frictional force developing under loading conditions at the area of contact. Friction, size, and number of wear particles were influenced by the similarity as well as the hardness of the surface contact of dry, unlubricated metals and quantitative predictions on friction or wear of unlubricated metals under different sliding conditions were not obtained. Testing of unlubricated, contacting metal surfaces for friction, wear, metal transfer, and surface finish was found to be the best method to assure compatibility and proper lubrication. G.G.

**N66-24550\*#** Tyco Labs., Inc., Waltham, Mass.  
**DEVELOPMENT OF CATHODIC ELECTROCATALYSTS FOR USE IN LOW TEMPERATURE  $H_2/O_2$  FUEL CELLS WITH AN ALKALINE ELECTROLYTE Second Quarterly Report, Oct. 1-Dec. 31, 1965**

A. C. Makrides, J. Giner, and R. J. Jasinski [1965] 124 p refs

(Contract NASw-1233)  
(NASA-CR-70930) CFSTI: HC \$4.00/MF \$1.00 CSCL 07D

During this period 58 materials and 10 elements were tested for corrosion resistance and activity as oxygen electrodes in 2 N KOH at 75°C. The technique was used to measure the current potential curve with rotated compact electrodes immersed in KOH solutions saturated with nitrogen or oxygen. Of the tested elements, Pd shows good  $O_2$  activity which is only slightly inferior to Pt. Graphite shows good intrinsic activity and iron with  $O_2$  reduction at  $E=600$  mv is more active than nickel. The experiments with intermetallic compounds show that under conditions of  $O_2$  reduction, the fundamental factor determining the activity is the atomic factor. Compounds of Pt and Au show an  $i(E)$  curve for  $O_2$  reduction



similar to those of pure Pt and Au. In some cases such as TaPt<sub>2</sub>, the activity of the intermetallic compound is very close to the activity of pure Pt. The solid solution Co<sub>2</sub>Ni shows a behavior which confirms the catalytic activity of Co<sup>3+</sup> containing oxide and the poor activity of the bivalent oxide. An iron carbide shows better activity for O<sub>2</sub> reduction than Fe. Metallographic characterization of 18 samples of prepared intermetallic compounds shows that where a simple phase was expected, a predominant phase with little or no second phase was obtained. R.N.A.

**N66-24565#** Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.

#### **TITANIUM CORROSION IN AQUEOUS SOLUTIONS**

Sam M. Weiman Feb. 1965 40 p refs Submitted for Publication /ts Eng. Paper No. 1799

Experimental results on the corrosion behavior of titanium in aqueous solutions are reported. A corrosion mechanism is based on the capability of achieving and maintaining a critical tetravalent titanium ion equilibrium concentration, [Ti<sup>4+</sup>]<sub>c</sub>. The corrosion film appears to play a part in this model. It is considered that the film may occur in two forms, one of which is soluble and the other is not. The soluble form is thought to be in equilibrium with [Ti<sup>4+</sup>]<sub>c</sub> and thus contribute to the apparent corrosion resistance of the system as well as to explain some of the experimental results. A discussion of the implications, including practical applications of this mechanism, is presented. Author

**N66-24604\*#** Mechanical Technology, Inc., Latham, N.Y. **LUBRICANT LIFE TESTS ON BALL BEARINGS FOR SPACE APPLICATIONS Final Report**

S. F. Murray and P. Lewis 26 Oct. 1965 85 p refs (Contract NAS5-9020)

(NASA-CR-71695; MTI-65-TR-55) CFSTI: HC \$3.00/MF \$0.75 CSCL 131

An experimental program has been conducted to compare the effective lives of ball bearings operating in vacuum with various types of MoS<sub>2</sub> solid films, and with a special high vacuum oil, as lubricants. The test bearings were size 205 bearings running at 30 rpm under a ten-pound radial load. Two particular combinations were also evaluated in oscillating motion tests. Torque was used as the criterion for failure. The results showed that most of the solid film lubricated bearings were effective for the first several hundred hours, then gave high and erratic torque values as the result of debris being formed by wear of the lubricant film. A sodium silicate bonded solid lubricant film, which contained MoS<sub>2</sub> and graphite, was found to be particularly promising in both rotation and oscillation. One particularly significant result was the finding that the oil-lubricated bearings showed a sudden, large increase in torque after running effectively for about 1400 hours in vacuum. This behavior has often been predicted but has apparently never been observed experimentally, at least for rolling contact bearings. Author

**N66-24697\*#** General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

#### **POTASSIUM CORROSION TEST LOOP DEVELOPMENT Quarterly Progress Report No. 9, 15 Jul.-15 Oct. 1965**

E. E. Hoffman, ed. [1965] 48 p refs

(Contract NAS3-2547)

(NASA-CR-54912) CFSTI: HC \$2.00/MF \$0.50 CSCL 20M

The boiling and condensing operation of the prototype corrosion test loop reached test conditions and the loop was run for 1785 hours of stable operation. The running operation procedures are outlined, and the temperature and pressure data are presented in graph form. The stability in the potassium cir-

cuit was attributed mainly to the pressure drop across the metering valve at the preheater inlet and to the wire wound plug section located in the first 12 inches of the boiler. Argon and nitrogen/carbon monoxide were the principal gasses in the chamber, and at the end of the test period were responsible for approximately 83% of the pressure. Argon instabilities in the getter-ion pump were reported. The test chamber environmental monitoring, boiler performance, and calibration of sodium and potassium flowmeters are discussed. Analysis of loop performance indicated that the variations between actual test and design test conditions were minor. No trends toward component degradation were detected. N.E.N.

**N66-24725#** Battelle Memorial Inst., Columbus, Ohio.

#### **A STUDY OF SLEEVE BEARINGS IN AIRCRAFT SUPPORT STRUCTURES Summary Report**

W. A. Glaeser, M. F. Amateau, and C. M. Allen 1 Feb. 1966 47 p

(Contract NOW-62-0432-c)

(AD-620337) CFSTI: HC \$2.00/MF \$0.50

A research program was conducted to develop design information and data for plain airframe bearings. The type of information developed in this program included bearing life, load-carrying ability, frictional characteristics, and bearing wear rates. Emphasis was placed on grease-lubricated, high-strength steel bearings and self-lubricating Teflon-fabric bearings. Prior to the experimental work, a survey was made of airframe manufacturers to determine the present and future needs for plain-bearing design information. Based on the results of the survey, bearing materials were selected and their operating characteristics measured in an airframe-bearing-evaluation apparatus. TAB

**N66-24732#** Wisconsin Univ., Madison.

#### **MECHANISM OF STRESS CORROSION CRACKING IN FACE-CENTERED-CUBIC METALS Final Technical Report**

R. A. Dodd [1965] 5 p refs

(Grant AF-AFOSR-221-63)

(AFOSR-65-2702; AD-628085) CFSTI: HC \$1.00/MF \$0.50

The work was designed firstly to examine the possibility of the existence of a universal mechanism of transgranular stress corrosion cracking, originally postulated by Robertson and Tetelman, and later, when such a mechanism was substantially disproved, to examine possible cracking mechanisms in various alloy systems of interest. The experimental techniques employed included the determination of times to complete fracture under stress corrosion conditions, potentiostatic studies of polarization phenomena, etc., and electron microscope investigations of dislocation configurations and estimates of the related stacking fault energies. TAB

**N66-24781#** IIT Research Inst., Chicago, Ill. Technology Center.

#### **DEVELOPMENT OF A RUST-REMOVING CORROSION PREVENTATIVE Final Report, May 21, 1964-May 20, 1965**

David B. Boies Aug. 1965 44 p refs

(Contract DA-11-070-AMC-481(W))

(IITRI-C6032-17; AD-626186) CFSTI: HC \$2.00/MF \$0.50

Removable corrosion preventatives were developed that, when applied to rusted steel or iron surfaces, remove or adsorb the rust during storage and prevent further deterioration. It was necessary to use semipolar wax-base materials in order to provide sufficient rust-removing activity. Fatty amides were used as the wax base in all of the formulations. The rust-removing activity was supplied by materials of an acidic nature, p-toluene sulfonic acid or salicylic acid, or by chelating agents

of the beta-diketone class. The diamide of oleic acid and diethylenetriamine was added as a corrosion inhibitor. The formulations are effective in removing light rust films, and they provide protection against rerusting under inside storage conditions. Author (TAB)

**N66-24820#** Monsanto Research Corp., Everett, Mass.  
**EFFECTS OF SELECTED STRAINS OF MICROORGANISMS ON THE COMPOSITION OF FUELS AND LUBRICANTS**  
**Final Report, 1 Sep. 1962-27 Nov. 1964**

Glenn R. Wilson, John O. Smith, H. F. Martin, Dolph Klein, E. C. Harrington et al. Wright-Patterson AFB, Ohio, Res. and Technol. Div., Jan. 1966 154 p refs  
 (Contract AF 33(657)-9814)  
 (RTO-TDR-63-4117, Pt. II; MRB-2023F, AD-628673)

A select number of aerobic bacterial and fungal cultures (isolates from contaminated fuel tank bottoms) were screened against a variety of jet fuels (JP-4 and JP-6), a lubricant, a liquid rocket propellant, and a spectrum of pure hydrocarbons (naphthenes and normal and branched alkanes) for growth-supporting properties. Variable growth support on all jet fuel samples was noted with the exception of one which was found to contain no detectable normal alkanes. Removal of normal alkanes from the other jet fuel samples significantly reduced their growth-supporting properties. The normal alkanes supported the most growth, the 2-methyl and 2,2-dimethyl alkanes lesser growth, and the naphthenes no growth support. After the prolonged incubation of several of the bacterial cultures on the initially resistant jet fuel sample, several cultures adapted to it. A variety of jet fuel additives were also screened against bacterial cultures and certain types were found to inhibit growth. Author (TAB)

**N66-25004#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**COMPATIBILITY OF COLUMBIUM AND TANTALUM TUBING ALLOYS WITH REFLUXING POTASSIUM**

Coulson M. Scheuermann and Charles A. Barrett Washington, NASA, May 1966 45 p refs  
 (NASA-TN-D-3429) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

The corrosion resistance of potential columbium and tantalum tubing alloys to refluxing potassium was tested at temperatures bracketing the maximum expected use temperature of the advanced turboelectric space power systems, 1800° to 2400°F. Tests were conducted with reflux capsules. The capsule wall served as the test specimen. The initial oxygen content of the potassium was a maximum of 20 parts per million as determined by mercury amalgamation and vacuum distillation techniques. The oxygen content of the materials was generally 100 to 200 parts per million. The tests were performed in a vacuum of 10<sup>-7</sup> to 10<sup>-8</sup> torr for times up to 4000 hours. The materials studied were the columbium alloys B-33, SCb-291, Cb-1Zr, D-14, B-66, FS-85, AS-55, D-43, C-129, and Cb-752; and the tantalum alloys Ta-10W, T-111, and T-222. The gettered alloys containing the reactive elements zirconium or hafnium were found to be more resistant to corrosive attack than the ungettered alloys under the test conditions. A mechanism is proposed, based on experimental results, that describes the oxygen accelerated corrosive attack of columbium and columbium alloys by potassium under refluxing conditions, involving the formation and solution of complex oxides. This mechanism may be expected to be applicable, in principle, to the other refractory metal-alkali metal systems as well. Author

**N66-25094#** Bettis Atomic Power Lab., Pittsburgh, Pa.  
**DEVELOPMENT OF ZIRCONIUM-BASE ALLOYS**

W. F. Bourgeois and J. N. Chirigos Nov. 1965 44 p refs  
 (Contract AT(11-1)-GEN-14)  
 (WAPD-TM-546) CFSTI: HC \$2.00/MF \$0.50

An experimental program was conducted in order to develop an alloy having corrosion resistance superior to Zircaloy-2 in steam at temperatures greater than 750°F but with hydrogen pickup and corrosion resistance in water at least equal to that of Zircaloy-2. Corrosion results, hydrogen absorption, hardness, and some tensile data are presented for six zirconium-base alloys containing from 0 to 1 wt% tin, iron, and chromium after 311 days in 680°F water, 259 days in 850°F steam (1500 psi), 176 days in 950°F steam (1500 psi), and 30 days in 1150°F steam (15 psi). It was concluded that four alloys are particularly promising for high-temperature steam applications and, of these, a ternary alloy of sponge zirconium with 0.5 wt% iron and 1.0 wt% chromium appears to have the best combination of overall properties.

Author (NSA)

**N66-25284#** Joint Publications Research Service, Washington, D.C.

**ANTICORROSIVE PLASTIC COATINGS**

V. G. Samsonov, V. G. Kharakhash et al 11 May 1966 71 p refs Transl. into ENGLISH of the book "Protivokorroziionnyye Plastmassovyye Pokrytiya" Kiev, "Tekhnika" Publishing House, 1965 p 4-91  
 (JPRS-35452; TT-66-31888) CFSTI: \$3.00

The use of corrosion resistant polymeric materials for protective coatings on the inner surfaces of ferrous and stainless steel containers, pipes, and valves is discussed. Technological methods and pertinent data are presented for the economic and efficient use of these materials; and the results of a mechanical, chemical, and physical properties investigation are given. D.T.

**N66-25289#** General Dynamics Corp., Chicago, Ill. Liquid Carbonic Div.

**DESCALING AND DECONTAMINATION STUDIES**

T. F. D'Muhala 8 Jun. 1965 199 p refs  
 (SD-22)

A proprietary neutral descaling formulation designated RD16 was used in comparison with existing descaling agents for all tests conducted on presoiled laboratory test coupons. Formula modifications extended the utility and effectiveness of RD16 without grossly affecting desirable characteristics of neutrality, low metal loss and stability. Decontamination experiments were performed on metal coupons which had been precontaminated. RD16 surpassed the requirements for a radioactive soil decontaminant. Tests were conducted on actual reactor system components. Comparative tests were performed simultaneously with existing, approved, methods of decontamination. When used in a multi-step process, RD16 appears to be as effective a decontaminant as other processes tested. Further evaluation established the safety associated with RD16 for materials of construction and personnel. Formula modification resulted in a family of neutral decontaminating solutions, each for a specific purpose. Tests conducted in actual systems corroborated test data as to effectiveness, safety and economics. Author

**N66-25768#** Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.

**A STOCHASTIC CHARACTERIZATION OF WEAR-OUT FOR COMPONENTS AND SYSTEMS**

Z. W. Birnbaum (Washington Univ.), J. D. Esary, and A. W. Marshall Sep. 1965 26 p refs Also issued as TR-46 by Washington Univ /Its Math. Note No. 420 (Contract Nonr-477(38)) (DI-82-0460)

It is well known that the future life distribution of a device remains the same regardless of the time it was previously in use, if and only if the life distribution of that device is exponential. For this reason exponential life distributions are accepted as characterizing the phenomenon of no-wear. The problem of finding a class of life distributions which would similarly reflect the phenomenon of wear-out has been under investigation for some time. In answer to this problem we introduce in this paper the class of IHRA (Increasing Hazard Rate Average) distributions and show that it has, among others, the following optimal properties: (i) it contains the limiting case of no-wear, i.e., all exponential distributions, (ii) whenever components which have IHRA life distributions are put together into a coherent system, this system again has an IHRA life distribution, i.e., a system wears out when its components wear out, and (iii) the IHRA class is the smallest class with properties (i) and (ii).

Author

**N66-25815#** Netherlands Research Centre TNO for Shipbuilding and Navigation, Amsterdam. Engineering Dept. **COMPARATIVE SHIPBOARD MEASUREMENTS OF SURFACE TEMPERATURES AND SURFACE CORROSION IN AIR COOLED AND WATER COOLED TURBINE OUTLET CASINGS OF EXHAUST DRIVEN MARINE DIESEL ENGINE TURBOCHARGERS** [VERGELIJKENDE METINGEN VAN CORROSIE EN WANDTEMPERATUREN IN LUCHT- EN WATERGEKOELDE TURBINEUITLAATHUIZEN VAN DRUK-VULGROEPEN VOOR SCHEEPSMOTOREN] R. W. Stuart Mitchell and V. A. Ogale Dec. 1965 14 p ref /Its Rept.-77M (TDCK-44575) CFSTI: HC \$1.00/MF \$0.50

This report deals with comparative surface temperature and surface corrosion measurements on the turbine outlet casings of an air cooled and of a water cooled exhaust driven turbocharger of a marine diesel engine using residual fuel. Results indicate that, for the turbocharger under investigation, air cooling is to be preferred to water cooling.

Author

**N66-25844#** General Electric Co., Schenectady, N. Y. Materials and Processes Lab. **DEVELOPMENT OF HOT-CORROSION RESISTANT ALLOYS FOR MARINE GAS TURBINE SERVICE** Final Summary Report Paul A. Bergman, Chester T. Sims, and Adrian M. Beltran 21 Jan. 1966 146 p refs (Contract N600(61533)63218) (MEL-131-66; AD-629786) CFSTI: HC \$4.00/MF \$1.00

A program was initiated to develop improved hot-corrosion-resistant alloys for Naval gas turbines. Two series of nickel-base alloys and one series of cobalt-base alloys plus appropriate commercial alloys were studied for possible service as blades and vanes, respectively. Hot-corrosion testing was conducted in two simulated gas turbine burner rigs, one designed particularly for this program. Test variables of temperature, air/fuel ratio, specimen configuration, and atomization effects have been studied using combusted diesel fuel and fixed amounts of sulfur and with salt injected. Proper conditions to achieve reproducible and discriminating hot-corrosion attack have been established. Relative behavior of both experimental and commercial alloys have been determined. The effects of individual element additions appear to have been identified in certain instances; in other cases, compositions were too complex for such separation. Thus, the effects of several elements in nickel-base alloys appear clear, but

longer-time testing is recommended for cobalt-alloys. Mechanical properties and microstructures of alloys designed for this program are studied and reported. Author (TAB)

**N66-25851#** Office of Naval Intelligence, Washington, D. C. Translation Section.

**PLASTICS-BASED ANTICORROSIVE COATINGS. SYNTHETIC COATINGS FOR SHIPS' HULLS** [SINTETICHESKIYE MATERIALY V SUDOSTROYENIE I SUDOREMONTE] [1966] 7 p Transl into ENGLISH from Morsk. Transp. (Moscow), 1962 p 150-158

(ONI-Transl.-2108; AD-629731) CFSTI: HC \$1.10/MF \$0.50

Anticorrosive synthetic paints for ship hulls are discussed. Painting procedures for ships with different sailing requirements are listed. The composition of various primers, and the application of ethanol paint are mentioned. Anticorrosive coverings of vinyl paints and paints based on epoxy resins are described, including the particular use and the number of layers recommended. It is pointed out that paints based on synthetic resins are most stable for ships sailing in tropical and sub-tropical waters. Paints are indicated for use as protection against molds, microorganisms, and insects such as termites. Paints for both the underwater and the above water sections of the hull are designated.

N E N

**N66-25854#** Mechanical Technology, Inc., Latham, N. J. **FRICTION AND LUBRICATION IN HOT METAL DEFORMATION**

Marshall B. Peterson and F. F. Ling 20 Mar 1966 98 p refs (Contract N0w-65-0363-c) (MTI-66TR18; AD-630204) CFSTI: HC \$3.00/MF \$0.75

A study was conducted to investigate the frictional behavior of metals in hot metal deformation. The purpose of the study was to gain a better understanding of friction at high pressures and temperatures characteristic of metal-working processes. A test technique was developed in which a thin foil was compressed between a hardened anvil and a flat plate. Friction was determined by applying a tangential force to one of the specimens. A technique was also developed to evaluate lubricants based upon the surface damage of various pure metals and alloys in both the lubricated and the unlubricated condition, at temperatures to 1800°F and pressures to 200,000 psi. It was found that this test uniquely yielded the friction coefficient of a given metal combination at a particular pressure and interface temperature. The variables found to be most significant in the pressure range 8000 to 200,000 psi are the roughness, temperature, surface oxide, and tool materials. Over this pressure range, friction is primarily determined by the strength of the metal. Adhesion effects modify the friction but primarily determine the extent of metal transfer.

TAB

**N66-25978#** Ohio State Univ. Research Foundation, Columbus.

**A STUDY OF THE MECHANISM OF STRESS CORROSION CRACKING IN THE IRON-NICKEL-CHROMIUM ALLOY SYSTEM** Quarterly Report, 17 Jun.-16 Sep. 1965

R. W. Staehle 12 Nov. 1965 54 p refs (Contract AT(11-1)-1319)

(COO-1319-32) CFSTI: HC \$3.00/MF \$0.50

Developments are reported for experiments on: time to cracking as affected by alloy, stress, dissolved oxygen, and sodium chloride; tensile properties as affected by temperature and alloy content; frequency of annealing twins as affected by alloy, cold work, and annealing temperature; electron metallography; and electrochemical studies. Work is under way to modify the circulating autoclave system in order to improve monitoring of data and to obtain better control of variables.

Author (NSA)

**N66-26038#** Commissariat à l'Energie Atomique, Saclay (France).

**CONTRIBUTION TO THE STUDY OF PITTING CORROSION OF MAGNESIUM AND ITS ALLOYS [CONTRIBUTION A L'ETUDE DE LA CORROSION PAR PIQUES DU MAGNESIUM ET DE SES ALLIAGES]**

Jean Blanchet (M.S. Thesis) 1965 51 p refs In FRENCH (CEA-R-2815)

The pitting attack of magnesium and its alloys was studied by means of potentiokinetic polarization curves; the following parameters have been considered: structural state and composition of the metal; chloride concentration; and pH of the medium. The electrochemical data obtained demonstrate that at pH 12, a localized corrosion might appear as soon as a  $10^{-3}$  M NaCl concentration is reached; on the other hand, at pH=13, a much higher concentration (five times) has no effect. In the same conditions, the coupling of magnesium with various noble materials (graphite, platinum, 18/10 stainless steel) also severely increases its susceptibility to pitting, but only when chloride ions are present in the solution. Usual corrosion tests confirmed these electrochemical results. A micrographic study of the pits showed that their morphology is connected with the metallurgical state of the specimens.

Author (NSA)

**N66-26057#** Societe d'Etudes, de Recherches et d'Application pour l'Industrie, Brussels (Belgium).

**DYNAMIC CORROSION TESTS OF CARBON STAINLESS STEEL IN PRESSURIZED WATER [ESSAIS DYNAMIQUES DE CORROSION D'ACIERS AU CARBONE ET INOXYDABLE DANS L'EAU PRESSURISEE]**

M. Warzee, P. de Dorlodot, and J. Waty Brussels, EURATOM, Mar. 1966 32 p refs In FRENCH; ENGLISH summary (Contract EURATOM-089-62-7 RDB)

(EUR-2688 f; EURAEC-1546) CFSTI: HC \$2.00/MF \$0.50

A grade of austenitic 18-10 stainless steel (AISI 304) with 0.04% C and a grade of low alloy steel used in boiler manufacturing have served as basic material for the tests. Four quite different surface treatments have been compared: tool machining, grinding, mechanical polishing up to grade 600 and electrolytic polishing in an aceto-perchloric bath. It has been examined if the influence of the surface state upon corrosion at 300°C, which appeared in static conditions, still persisted under dynamic conditions at flow speeds comprised between 2 and 18 m/sec. In the case of AISI 304 steel, it appears that the advantage gained with electrolytic polishing remained provided the speed did not exceed 5 m/sec. At higher flow speeds, (10 and 18 m/sec.), a levelling of corrosion results for all surface states appears, together with an appreciable lowering of corrosion at 18 m/sec. As concerns boiler steel, it is noted that the advantage gained by electropolishing, appearing under static conditions, disappeared in dynamic tests, even at 2 m/sec. This must probably be explained by important erosion-corrosion phenomena characterizing this type of steel under dynamic conditions. A proportion of 90 to 99% of total corrosion is due to the release of oxide to the system, with almost linear kinetics rating from 150 to 400 mg/dm<sup>2</sup>/month for flow speeds of 2 to 10/sec.

Author

**N66-26104#** Joint Publications Research Service, Washington, D. C.

**MOTION OF AN INTEGRATING GYROSCOPE WITH DRY FRICTION**

N. V. Butenin and A. M. Lestev In its Izv. VUZov: Instr. Bldg., No. 6 12 May 1966 p 112-121 refs (See N66-26086 14-14) CFSTI: \$6.00

The motion of the axis of an integrating gyroscope which is experiencing dry friction is considered. Expressions are given which define the system, and equations are derived which satisfy the specified parameters. It is stated that the forces

of dry friction introduce a number of peculiarities into the motion of the axis of the integrating gyroscope, and that a critical value of the angular velocity of the base exists. Additionally it was found that for certain relationships between the parameters of the gyroscope and the vibration, the dry friction forces cause a new type of motion—motion with long pauses. It was concluded that the unsymmetrical dry friction forces cause a systematic deviation of the axis from the initial position, and the greatest errors due to the dry friction forces are caused when the axis moves with long pauses.

H.S.W.

**N66-26118#** Joint Publications Research Service, Washington, D. C.

**A COMPARATIVE ANALYSIS OF THE TURNED, GROUND, BURNISHED AND VIBRO-BURNISHED SURFACES FOR WEAR AND SEIZURE**

L. A. Bunga In its Izv. VUZov: Instr. Bldg., No. 6 12 May 1966 p 194-201 refs (See N66-26086 14-14) CFSTI: \$6.00

Steel bearing specimens were used and the experimental procedures are described in detail. The results of the investigations into the effects of the size of the bearing surface on the resistance to seizure are illustrated in a diagram. In analyzing this diagram, it is stated that the resistance to seizure is determined by the size of the bearing surface and by the shape of irregularities and their uniformity. Friction with and without lubrication was also considered, and it was determined that the character of the change in the moment of friction in the seizure is analogous to the change in the specific pressure. Fluid friction does not change the character of the relationships, but delays the instant of the seizure approximately 2.5 times. Additional conclusions are drawn and evaluated.

H.S.W.

**N66-26152#** Joint Publications Research Service, Washington, D. C.

**THE METHOD AND EQUIPMENT FOR THE INVESTIGATION OF ELECTRIC EROSION BY REPEATED DISCHARGES**

A. A. Namatev and G. A. Ostroumov In its Electron. Treat. of Mater. 2 May 1966 p 11-15 refs (See N66-26150 14-34) CFSTI: \$4.00

This report describes a method and its associated equipment for determining the electric erosion of metals by repeated discharges. The method involves the successive oscillographing of the discharge processes taking place under the same initial energy conditions which are taken from the statistical distribution of the breakdown voltage with the aid of a differential amplitude discriminator. The oscillograms show only the properties of those sections of the electrode surfaces between which the discharge appears directly. The oscillographing can be performed by using an OK-17M two beam oscillograph and Negativ-DK type photographic material. The voltage from the discharge gap is supplied directly to the deflecting plates of the electron beam tube. The discharge current is fixed with the aid of a shunt with its inductance compensated up to frequencies of 1 to 1.2 megacycles through the amplifier of the oscillograph's first channel. The integral erosion of the electrodes, the value of the microroughness, the composition and the mass of the products of pyrolysis, etc., are then all determined by the serial method. A more detailed description of the equipment and some of the oscillograms obtained with this method are included.

R.N.A.

**N66-26154#** Joint Publications Research Service, Washington, D. C.

**THE MEDIA FOR ELECTRO-EROSION TREATMENT OF METALS**

A. N. Merkur'yev, N. S. Pechuro, L. A. Royter, V. N. Gol'din, and O. Yu. Pesin In its Electron. Treat. of Mater. 2 May 1966 p 21-38 (See N66-26150 14-34) CFSTI: \$4.00

This report examines the results of experimental investigations on the effect of the composition of certain organic and inorganic media on the process of erosion. The study showed that the electro-erosion process of making apertures in a medium composed of various organic compounds illustrates the effect of their physical and chemical properties on the output of the process of treatment. In making apertures, a maximum erosion is observed when aromatic compounds and polyethyl-siloxanes are used as the media between the electrodes. In the cutting of metals, the use of aqueous solutions of electrolytes as media between the electrodes makes it possible to improve the cleanliness of the surface of the treated parts by the joint action of the electro-erosion and electrochemical processes.

R.N.A.

**N66-26219#** Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.

**FLOW OF A NONLINEAR VISCO-PLASTIC MEDIUM BETWEEN TWO PLATES**

A. A. Tamonov *In its Invest of Elasticity and Plasticity* 11 Jan. 1966 p 244-254 refs (See N66-26206 14-32) CFSTI: HC \$7.05/MF \$1.75

This article presents a generalization to the problem of flow between inclined plates for the case of a medium with a power dependence of plastic viscosity on strain rates, and also a generalization to the problem of a non-Newtonian liquid with an analogous dependence of effective viscosity on velocity gradient, i.e., when limiting shear stress is absent.

R.N.A.

**N66-26483#** General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.

**STAINLESS STEEL FAILURE INVESTIGATION PROGRAM Second Quarterly Progress Report, 1 Jul.-30 Sep. 1965**

T. J. Pashos, comp. Oct 1965 57 p refs (Contract AT(04-3)-189)

(GEAP-4968; EURAEC-1541) CFSTI: HC \$3.00/MF \$0.75

Results of 24 hrs stainless steel in boiling  $\text{HNO}_3\text{-K}_2\text{Cr}_2\text{O}_7$  indicate that irradiation exposure increases susceptibility to corrosion. The weight loss of irradiated cladding samples was consistently higher than that of unirradiated control specimens by a factor of two. Autoclave testing in high temperature  $\text{FeCl}_2$  solutions was improved to reproducibly produce intergranular cracking of type 304 stainless steel. There was a marked difference in results of corrosion tests in  $\text{FeCl}_2$  solution between unirradiated commercial type 304 stainless steel cladding and the cladding from co-extruded  $\text{UO}_2$  in stainless steel fuel rod. Commercial tubing cracked intergranularly in from 1 to 2 days whereas the co-extruded specimen had not failed after 8 days exposure. Tensile tests at 650° F and at strain rates of 0.024 and 0.0024 in/in/min and at constant load were performed on irradiated cladding samples. The tensile fractures were all transgranular and ductile with no evidence of intergranular separation. Electron microscopy was performed on an incipient crack that extended one-third of the way through the cladding. The tips of the crack were observed to be rounded with no evidence of mechanical fracture.

Author (NSA)

**N66-26504#** Air Force Systems Command, Wright-Patterson AFB, Ohio, Foreign Technology Div.

**MOLTEN METALS AS HIGH-TEMPERATURE LUBRICANTS**  
N. M. Fialko and A. I. Dintses 20 Jan. 1966 11 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 3, 1964 p 54-58

(FTD-TT-65-1447/1+2+4; AD-629415) CFSTI: HC \$1.00/MF \$0.50

Investigations of molten metals for use as lubricants is reported. The procedures of the experiments to determine corrosive aggressiveness and diagrams of the apparatus are included. The corrosive aggressiveness of bismuth, cadmium,

tin, lead, zinc, and two eutectic alloys were evaluated. A method of predicting the metallic interactions was devised. It was pointed out that at 500° C all metals oxidize in air, and that therefore the metals must be placed in an inert atmosphere or a high vacuum. The interaction of liquid metals with construction alloys, the high specific gravity of metals, and their relatively high cost were mentioned. On the basis of these considerations, it was concluded that the development of liquid lubricants for use at 400-700° C should be done with inorganic salts.

N.E.N.

**N66-26576#** Southwest Research Inst., San Antonio, Tex. Dept. of Aerospace Propulsion Research.

**RESEARCH ON MITIGATION OF SPLINE WEAR BY MEANS OF LUBRICATION Quarterly Progress Report No. 3, 15 Nov. 1965-15 Feb. 1966**

W. D. Weatherford, Jr., M. L. Valtierra, and P. M. Ku 15 Feb. 1966 27 p refs

(Contract N0W-65-0224-f)

(RS-485; AD-639938) CFSTI: HC \$2.60/MF \$0.50

Experiments were made to investigate the effect of hydrocarbon antioxidants on the spline wear observed when operating submerged in mineral oil. The results indicate that certain hydrocarbon antioxidants provide periods of negligible wear which otherwise do not occur in air-saturated mineral oil. The observed antioxidant effect and previously reported influences of environment composition are tentatively interpreted in terms of postulated wear mechanisms.

Author (TAB)

**N66-26654#** IIT Research Inst., Chicago, Ill. Technology Center.

**ENVIRONMENTAL STUDY OF MINIATURE SLIP RINGS Quarterly Report No. 11, 1 Jan.-1 Apr. 1966**

O. M. Kuritza [1966] 15 p

(Contract NAS8-5251)

(NASA-CR-75119; E6000-32) CFSTI: HC \$1.00/MF \$0.50 CSCL 13H

Work was begun on a sublimation technique to lubricate slip rings in a high vacuum. A run-in test of a hard gold overlay was conducted in a nitrogen atmosphere; and sufficient debris was collected to perform a qualitative spectrographic analysis for determination of organic constituents. In an attempt to improve noise performance, the brush was redesigned; no substantial improvement was obtained, however. Nickel-soft gold plated rings were prepared for testing in a nitrogen atmosphere; and preparations were completed for testing in a high vacuum using an ion pump.

D.T.

**N66-26759#** Tyco Labs., Inc., Waltham, Mass.

**DEVELOPMENT OF CATHODIC ELECTROCATALYSTS FOR USE IN LOW TEMPERATURE  $\text{H}_2/\text{O}_2$  FUEL CELLS WITH AN ALKALINE ELECTROLYTE Third Quarterly Report, Jan. 1-Mar. 31, 1966**

J. Giner, A. C. Makrides, and R. J. Jasinski [1966] 102 p (Contract NASw-1233)

(NASA-CR-75199) CFSTI: HC \$4.00/MF \$0.75 CSCL 07D

A variety of metals; alloys; intermetallics; refractory metal compounds; and dispersed metals, alloys, and carbides were tested for corrosion resistance and activity as oxygen electrodes in potassium hydroxide at 75° C as part of an effort to improve the over-all efficiency of hydrogen-oxygen fuel cells. The preparations of specimens as solid ingots, cones, or as dispersed powders are outlined. Both rotating disk and floating electrode assemblies were used for the testing. Current-potential curves were measured for the one piece ingot type specimens. Of the elements tested, manganese showed activity for the reduction of  $\text{O}_2$  above +800 mv. In general the performances of electrodes prepared directly from platinum blacks were inferior to commercial electrodes; but a porous silver electrode which was constructed proved

superior in performance at high potentials (925mv-975mv) to the best of the commercial platinum electrodes. Severe corrosion was observed in all cases where borides, and silicides of the group IVB, VB, and VIB were tested. TiN showed significant activity for the reduction of  $O_2$ , being more active and more corrosion resistant than titanium metal. Current-potential curves obtained from the various tests are presented. L.S.

**N66-27009#** Naval Research Lab., Washington, D. C.  
**FACTORS AFFECTING THE ICING RESISTANCE OF LUBRICANTS FOR AIRCRAFT ORDNANCE**

H. R. Baker and R. N. Bolster *In its* Rept. of NRL Progr. Jan. 1966 p 1-5 refs (See N66-27008 15-15)

Recent samples of the all-weather semifluid lubricant for aircraft ordnance, obtained both from manufacturers and from Navy stocks, have failed to meet the cold-sweat-cold gun firing test required by Military Specification MIL-L-19701 (NOrd). These failures were due to ice adhesion attendant on the poor water resistance of the lubricants. The probable cause of the loss in water resistance was the presence of surface-active impurities, such as sodium soaps and soaps of myristic and oleic acids, in the lithium stearate thickener. A lubricant of altered formulation has been developed that is superior to the original. Variations in consistency over a wide temperature range are much less, and resistance to water and to ice adhesion are increased. It has been used successfully to lubricate the Mk 12 machine gun equipped with the Mk 7 pneumatic feeder under ambient temperature and cold-sweat-cold conditions. Author

**N66-27083#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**COMPONENT HARDNESS DIFFERENCES AND THEIR EFFECT ON BEARING FATIGUE**

E. V. Zaretsky, R. J. Parker, and W. J. Anderson [1965] 17 p refs Presented at the Lubrication Conf., San Francisco, 11-13 Oct. 1965 Sponsored by ASME and Am. Soc. of Lubrication Engr.

(NASA-TM-X-52087) CFSTI: HC \$1.00/MF \$0.50 CSCL 131

The five-ball fatigue tester and full-scale rolling-element bearings were used to determine the effect of component hardness differences of SAE 52100 steel on bearing fatigue and load capacity. Maximum fatigue life and load capacity are achieved when the rolling elements of a bearing are one to two points (Rockwell C) harder than the races. There appears to be an interrelation among compressive residual stresses induced in the races during operation, differences in component hardness, and fatigue life. Differences in contact temperature and plastically deformed profile radii could not account for differences in fatigue life. Author

**N66-27101#** Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.

**AN EVALUATION OF THE CORROSION RESISTANCE OF SEVERAL HIGH TEMPERATURE ALLOYS FOR NUCLEAR APPLICATIONS**

T. T. Claudson and R. E. Westerman Nov. 1965 32 p refs (Contract AT(45-1)-1830)

(BNWL-155) CFSTI: HC \$2.00/MF \$0.50

The results showed the comparative oxidation resistance of 10 high-temperature alloys in an oxidizing environment of helium and water vapor. It was found that large weight gains are primarily associated with intergranular corrosion and internal oxidation of the alloy. At 815°C in an atmosphere of low pressure water vapor, Hastelloy C, Hastelloy N, Hastelloy X-280, Inconel 600, Inconel 625, and Haynes 25 have more superior corrosion resistance than the other four materials tested. Weight gains of less than 0.3 mg/cm<sup>2</sup> were observed for these better materials after 300 hr of exposure. Inconel 718, Inconel 702, and Incoloy 800

were more resistant to corrosion than Hastelloy R-235, the least corrosion resistant of all the alloys tested at this temperature. At 930°C, the same relative grouping was found as in the 815°C data. However, more definite evidence of intergranular attack was found in Haynes 25, Inconel 718, and Inconel 600 at 930°C than at the 815°C test temperature. At 1038°C, definite and gross intergranular attack and internal oxidation was found in alloys. Hastelloy C, Hastelloy N, Hastelloy X-280, and Haynes 25 exhibit the best resistance to oxidation, and Inconel 600, Inconel 702, Incoloy 800, and Inconel 625 followed in order. At all test temperatures, Hastelloy R-235 showed the worst attack. Inconel 625 exhibited increasing amounts of grain boundary attack and subsequent internal oxidation with increasing test temperature. NSA

**N66-27134#** Atomics International, Canoga Park, Calif.  
**SNAP REACTOR MATERIALS DEVELOPMENT, ULTRA-HIGH-VACUUM FRICTION STUDIES**

L. G. Kellogg 8 Jun. 1964 74 p refs

(Contract AT(11-1)-GEN-8)

(NAA-SR-9644) CFSTI: HC \$3.00/MF \$0.75

Experimental studies were conducted to determine what materials can be used in SNAP design to provide bearing compatibility. Screening tests were conducted on sixty-seven material pairs in sliding couple at ultrahigh vacuum. The friction couples are categorized into seven groups: metal vs metal, metal vs metal with dry lubricants, metal vs carbon, ceramic vs ceramic, ceramic vs ceramic with dry lubricants, metal vs ceramic, and ceramic vs carbon. Special tests were conducted using contaminant films with all groups. The theory is discussed together with practical applications. Data are presented to illustrate the effects of vacuum on sliding friction and the effects of vacuum on surface film formation. Results indicate that carbon-graphites and sodium-silicate bonded dry-film lubricants provide relatively low friction in vacua at 100°F when coupled with  $Al_2O_3$  (flame sprayed) surfaces. Data are when coupled with  $Al_2O_3$  (flame sprayed) surfaces. Data are presented to show how both the carbon-graphites and dry films may be used together to provide a low friction couple through the temperature range of 70° to 800°F while operating in high vacuum. Results also indicate that sintered carbon materials provide relatively high friction in vacua at 1000°F when coupled with metallic surfaces. Several possible brake materials are discussed. Data of friction coefficient vs temperature and friction coefficient vs 1000-in. travel are presented for possible brake material couples. The test facility and the test method by which these studies were conducted is also included to provide insight into the technique employed and the results of the data. Author (NSA)

**N66-27232#** Westinghouse Electric Corp., Pittsburgh, Pa. Research Labs.

**LUBRICANT STUDY IN ULTRAHIGH VACUUM AND IN VARIOUS GAS ENVIRONMENTS** Final Report, 26 Jan. 1965-16 Mar. 1966

P. H. Bowen, D. J. Boes, K. W. Grossett, and E. S. Bober [1966] 155 p refs

(Contract NAS9-3815)

(NASA-CR-65374) CFSTI: HC \$5.00/MF \$1.00 CSCL 11H

Wear and friction characteristics of lubricated and unlubricated hardened stainless steel couples in sliding and rolling contact were studied in an ultrahigh vacuum environment and in an UHV environment degraded by outgassing products known to exist in spacecraft. The lubricants were of the fluid, laminar film, and solid composite types. The UHV environments were degraded by high purity  $CO_2$ ,  $O_2$ , and  $H_2O$  vapor. Results are compiled and presented in graphic form. Lubrication effectiveness is presented by a comparison of measured

friction values and of the metal component wear rates. Selected wear surfaces were analyzed by various laboratory techniques. The best overall lubrication was obtained with a  $\text{Na}_2\text{SiO}_3$  bonded  $\text{WSe}_2$  laminar film, followed by chlorophenyl methyl silicone oil. A self-lubricating composite wiper material was satisfactory to marginal lubrication and was more effective on rolling surfaces than on sliding contact surfaces. The  $\text{H}_2\text{O}$  vapor degraded UHV environment provided the most beneficial effect to lubricants. The composite lubricated surfaces received the least benefit and in several tests the effect was slightly detrimental. R.N.A.

**N66-27392#** Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Burssels (Belgium).

**DYNAMIC CORROSION TESTS ON CARBON AND STAINLESS STEELS IN PRESSURIZED WATER**

M. Warzee, P. De Dorlodot, and J. Waty 6 Dec. 1965 28 p refs Transl. into ENGLISH from French *Its Spec. Rept.-4* (Contract EURATOM-089-62-7 RDB)

(EURAC-1546; EUR-2688) CFSTI: HC \$2.00/MF \$0.50

Type 304 stainless steel with 0.04% C and Creusot 12 MDO7 steel were used as the basic materials for the tests. Four quite different surface treatments were compared: milling, grinding, mechanical polishing up to grade 600, and electrolytic polishing. The research was designed to determine whether the influence of the surface state on corrosion at 300°C, which had appeared under static conditions, persisted under dynamic conditions at flow rates between 2 and 18 m/sec. In the case of AISI 304 steel, it appears that the advantage gained with electrolytic polishing remained, provided the water flow rate did not exceed 5 m/sec. At higher flow rates (10 and 18 m/sec.), a leveling of corrosion results for all surface states appears, together with an appreciable lowering of corrosion at 18 m/sec. As regards Creusot 12 MDO7 steel, it is noted that the advantage gained by electrolytic polishing, which appeared under static conditions, disappeared in dynamic tests, even at 2 m/sec. This is undoubtedly due to the intense oxidation-erosion phenomena characterizing the behavior of this type of steel under dynamic conditions. A proportion of 90 to 99% of total erosion is due to the release of oxide to the system, which follows almost linear kinetics at the rate of 150 to 400 mg/dm<sup>2</sup>/month, depending on whether the rate is 2 or 10 m/sec. Author (NSA)

**N66-27404#** Rocky Flats Div., Dow Chemical Co., Golden, Colo.

**THE EFFECT OF COMPOSITION ON THE CORROSION OF PLUTONIUM METAL**

M. A. Thompson 3 Feb. 1965 5 p refs (Contract AT(29-1)-1106)

(RFP-511) CFSTI: HC \$1.00/MF \$0.50

Detailed spectrographic analysis, metallography, and electron microscopic examinations were conducted on a large number of plutonium samples that had been stored under approximately the same conditions for periods up to several years. The samples were stored in 1 atm of helium and generally outgassed 1 to 2 mm of gas, primarily hydrogen. Storage time was up to 2 yr. The results for allowed delta phase plutonium showed that Cr, Fe, Mn and the total impurity contents were significantly higher in the corroded samples. Just the opposite was found to be true for the unalloyed metal. NSA

**N66-27561#** Combustion Engineering, Inc., Windsor, Conn. Nuclear Div.

**CORRELATIONS BETWEEN SENSITIZATION AND STRESS CORROSION CRACKING OF 300 SERIES STAINLESS STEELS** Progress Report, 1 Jul.-30 Sep. 1965

J. J. Koziol and S. S. Christopher Oct. 1965 37 p refs (Contract AT(30-1)-3256) (CEND-3256-250; EURAEC-1508) CFSTI: HC \$2.00/MF \$0.50

Efforts were concentrated on procurement and installation of the test equipment, procurement of specimen materials, and design and fabrication of the test specimens. Checkout of the test system and chemical sampling procedures are currently underway. Arrangements for drawing, swaging, and application of a nickel surface layer to the tubing are being made. Author (NSA)

**N66-27598#** Army Foreign Science and Technology Center, Washington, D. C.

**EXPERIMENTAL STUDY OF THE EFFECT OF VIBRATIONS ON FRICTION IN THE CYLINDRICAL GUIDE-BEARINGS FOR A BALANCE-WHEEL SPINDLE**

A. P. Isayev Mar. 1966 16 p refs Transl. into ENGLISH from Izv. Vysshikh Uchebn. Zavedenii, Priborostr. (Leningrad), no. 4, Jul.-Aug. 1961 p 101-108

(FSTC-HT-23-40-66; AD-630853) CFSTI: HC \$1.60/MF \$0.50

The article presents the results of an experimental study pertaining to the effect of vibration on the friction torque in balance-wheel spindles and bearings of chronometers in general but 'Pobeda' and aviation instruments in particular. The effect of rotational speed and radial clearance between spindle journal and bearing bore, also the effect of the magnitude of a vibrational overload were tested. The significance of the position of the spindle relative to the earth's gravitational field is discussed. It is shown that the frictional torque can be made constant regardless of the angle of inclination of the spindle. The mutual relation between frictional torque and impact torque due to vibration is analyzed, and it is explained why, at vibrational overloads larger than 1 g, the impact torque becomes equal to zero. The impact torque refers to the spindle journal striking the inner bearing surface, while between strikes the spindle is in a suspended position. Author (TAB)

**N66-27661#** Naval Research Lab., Washington, D. C. **THE EFFECTS OF THREE AQUEOUS ENVIRONMENTS ON HIGH STRESS LOW-CYCLE FATIGUE OF 18% NICKEL MARAGING STEELS**

C. D. Beachem and T. C. Lupton Feb. 1966 33 p refs (NRL-Memo-1685; AD-631545) CFSTI: HC \$3.60/MF \$0.50

Base plate and weld specimens of 200 ksi and 250 ksi (nominal yield) grades of 18% Ni maraging steels were tested as side-grooved plane-strain cantilever beam specimens in distilled water, water 'inhibited' with  $\text{NaCrO}_4$ , and 3-1/2% NaCl solution, to determine the susceptibilities of these steels to both corrosion fatigue and sustained load crack growth. Stress intensities below which negligible crack growth occurred during twenty cycles were found to be about 95% of  $K_{Ic}$  for 250 grade base plate in distilled water, 73% of  $K_{Ic}$  for 250 grade tested in either the salt water or the sodium chromate solution, 88% of  $K_{Ic}$  for the 200 ksi grade base plate in all three environments, and essentially 100% of  $K_{Ic}$  for the 200 ksi weld metal in all three environments. Crack extension was found to be negligible in twenty cycles at a  $K_I$  of 65 ksi  $\sqrt{\text{in.}}$  in the 250 ksi grade welds in all environments. Author (TAB)

**N66-27676#** Rensselaer Polytechnic Inst., Troy, N. Y. **SURFACE TEMPERATURES AT SLIDING INTERFACES IN VACUA AND METAL ADHESION** Technical Documentary Report, 15 Nov. 1963-15 Feb. 1964

F. F. Ling Wright-Patterson AFB, Ohio, AF Mater. Lab., Mar. 1964 58 p refs

(Contract AF 33(657)-10058)

(ML-TDR-64-97; AD-631342) CFSTI: HC \$3.00/MF \$0.50

A friction and wear apparatus is described for use in vacua which has no supporting bearings other than the sliding surfaces whose friction and wear characteristics are to be investigated. The moving specimen is suspended and rotated magnetically, external to a vacuum chamber enclosing the test section. Typical temperature, friction and wear data are shown. Moreover, a mechanism of metal adhesion is postulated and a formula on the coefficient of adhesion derived. The experimental equipment to confirm the validity of the theory, at least phenomenologically, is described. The experimental equipment permits loading of predetermined amounts under varied temperatures and durations in vacua; the force of separation is then measured. The simple theory indicates the parameters of the problem: contact load, duration of loading, temperature at the interface, and cleanliness of the interface. The last item is measured through two quantities: (a) a reduced activation energy; and (b) a reduced time exponent of the process. The relationship between adhesion and friction is discussed.

Author (TAB)

**N66-27777#** Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).

**STUDIES OF STEEL CORROSION IN HIGH TEMPERATURE WATER AND STEAM** Quarterly Report No. 13, 1 Jul.-31 Oct. 1965

26 Nov. 1965 80 p Transl. into ENGLISH from French

(Contract EURATOM-089-62-7RDB)

(EURAE-1500; EUR-2658) CFSTI: HC \$3.00/MF \$0.75

The study of surface work-hardened stainless steels oxidized in steam at 400°C and above was continued. Morphological examination of the work-hardened metal zone under the fine oxide skin, formed by lengthy residence in superheated steam, showed the presence of precipitates, even where precipitation of chromium carbides is ruled out. It was previously supposed that this might be an internal oxidation phenomenon. Use of an electron microprobe did not reveal a regular oxygen-enriched zone. However, local oxygen concentrations were observed that may be attributed to discontinuous oxide penetrations which are, undoubtedly, connected with surface tearing by rough machining. The hypothesis identifying the precipitates seen under the microscope with internal oxides must therefore be rejected. X-ray diffraction examinations, with the grazing emergence of the diffracted rays corresponding to interreticular distances of close to 2 Å, showed the presence of  $\sigma$ -phase in the work-hardened zone of a milled sample of type 304 stainless steel oxidized for 1000 hr in steam at 500°C. This alteration in the work-hardened zone is the result of lengthy heat treatment in the 400° to 500°C temperature zone. When the precipitates were identified, the factor responsible for behavior on re-oxidation after scaling the initial oxide skin had still to be determined. Prior studies showed that the benefit of work-hardening treatment is partly preserved after initial oxidation for 1000 hr at 500°C, whereas it disappears after initial oxidation for 1000 hr at 600°C. It was established that, with type 410 stainless steel, 1000 hr at 500°C is enough to remove all benefits of surface work-hardening. The X-ray diffraction examinations, which identified the  $\sigma$ -phase, revealed that the work-hardened zone underwent partial or complete recrystallization according to the type of steel and the temperature of the initial 1000-hr oxidation treatment. The degree of recrystallization revealed in this way is in complete agreement with the relatively degraded behavior on re-oxidation.

Author (NSA)

**N66-27803#** Army Foreign Science and Technology Center, Washington, D. C.

**CORROSION PROTECTION BY COLD PHOSPHATIZATION** V. S. Lapatukhin 23 Feb. 1966 21 p refs Transl. into ENGLISH from Zh. Prikl. Khim. (Moscow), v. 24, no. 4, 1951 p 373-382

(FSTC-HT-23-24-66- AD-630848) CFSTI: HC \$2.60/MF \$0.50

Following a discussion of the shortcomings of the hot method of coating iron and steel with a phosphate solution for protection against corrosion, the author describes a method of cold phosphatization involving the use of zinc dihydrophosphate, fluorine compounds, and accelerators to decrease free acidity and promote depolarization of the hydrogen liberated by phosphatization. The high corrosion resistance and strength of the phosphate coatings were demonstrated in laboratory and industrial tests.

Author (TAB)

**N66-27871#** Rock Island Arsenal Lab., III. Research and Engineering Div.

**EVALUATION OF REMOVABLE FILM CORROSION PREVENTIVES** Final Technical Report

William F. Garland Mar. 1966 28 p refs

(RIA-66-774; AD-631326) CFSTI: HC \$2.00/MF \$0.50

Twelve pressure-sensitive tapes and one strippable vinyl plastisol material are evaluated for possible use as removable film corrosion-preventive materials. The materials were tested for fungus resistance and adhesion as well as for their ability to protect metals from corrosion and weathering. The tape backings were of three types: paper, plastic, and fabric. All materials were found to be fungus proof, and the tapes were tack-free during adhesion testing. A plastic-backed tape provided the best combination of protection (accelerated weathering, corrosion, and fungus resistance) and ease of removal of any of the tapes tested. A weather-resistant polyvinyl-fluoride-backed tape and the strippable vinyl plastisol were the two most corrosive materials tested.

Author (TAB)

**N66-27891#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**CORROSION STUDY XXIV: THE INFLUENCE OF TEMPERATURE ON THE PASSIVATION CHARACTERISTICS OF STAINLESS STEELS**

M. Prazak and J. Spanily 17 Mar. 1966 15 p refs Transl. into ENGLISH from the Publ. "Korrosionsstudium XXIV. Einfluss der Temperatur auf die Passivierungs-Charakteristik Korrosions-Bestandiger Stahle" 10 Aug. 1960 p 2828-2837

(FTD-TT-65-1223/1+2+3+4; AD-630974) CFSTI: HC \$1.60/MF \$0.50

The temperature dependence of the corrosion reaction in the range of the critical passivation current, in the range of passivity, transpassivity, and of secondary passivity were determined for two typical chrome-nickel stainless steels; the dependences were quantitatively expressed by the Arrhenius equation. Certain conceptions of the mechanism of the processes concerned were built up on the basis of the activation energy values of the respective reactions. From the results it can be seen that the corrosion, in a passive state, rises very steeply with increasing temperature (in the range of 20-210°C in a ratio of 1:10,000,000), so that it may become technically significant in the case of higher temperatures. The stability of the passive state and the passivation tendency of the material decrease with equal rapidity with increasing temperature. It has been found that the effectiveness of corrosion inhibition by means of passivating inhibitors decreases as a result of this.

Author (TAB)



**N66-27931\*** # SKF Industries, Inc., King of Prussia, Pa. Research Lab

**BEARING-LUBRICANT ENDURANCE CHARACTERISTICS AT HIGH SPEEDS AND HIGH TEMPERATURES** Final Report, Sep. 1-Aug. 31, 1965

C. J. Wachendorfer and L. B. Sibley [1965] 129 p refs

(Contract NASw-492)

(NASA-CR-75582, AL65T068) CFSTI: HC \$4.00/MF \$1.00 CSCL 11H

This study was performed to determine operability, critical mode of failure and life of angular-contact ball bearings of advanced design at high temperatures in excess of 500°F using the best available fluid lubricants in a recirculating system. 205-size 25mm-bore angular-contact ball bearings made of vacuum-melted tool steels having high hot hardness were tested with a number of high-temperature fluid lubricants representing hydrocarbons, esters, and polyphenyl ethers. The test machine was designed to simulate a typical aerospace accessory drive system with nitrogen blanketing to minimize lubricant oxidation at high temperature. Bearing design parameters and cage materials were developed for successful operation under the test conditions. Results were obtained from over 300 bearings tested with 17 different lubricants at high load (300 to 500 lbs. thrust) and speeds from 20,000 to 45,000 rpm. These results indicate that satisfactory operation is possible at bearing temperatures at least up to 600°F.

Author

**N66-28018\*** # National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**A REVIEW OF BALL MOTION IN AN ANGULAR CONTACT BALL BEARING**

R. J. Parker, E. V. Zaretsky, and W. J. Anderson, Washington, NASA, 1966 37 p refs Presented at the Am. Soc. of Mech. Engr. Spring Lubrication Symp., New Orleans, 6 Jun. 1966

(NASA-TM-X-52207) CFSTI: HC \$2.00/MF \$0.50 CSCL 131

A significant portion of total ball-bearing friction results from friction due to sliding or spinning in the contacts of the balls and races. A brief review of the nature of this ball-race contact including analyses of ball spin and microslip and the factors contributing to the problem are presented in this paper.

Author

**N66-28033\*** # National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Tex.

**STATUS OF LUBRICANTS FOR MANNED SPACECRAFT**

Frans G. A. de Laat (TRW Systems, Redondo Beach, Calif.), R. V. Shelton (N. Am. Aviation, Downey, Calif.), and J. H. Kimzey Jun. 1966 26 p refs Presented at the 21st Ann. Meeting of the Am. Soc. of Lubrication Engr., Pittsburgh, 2 May 1966

(NASA-TM-X-58002) CFSTI: HC \$2.00/MF \$0.50 CSCL 11H

This paper reports the status of lubricants selected for use on manned spacecraft such as Apollo. The selection of lubricants was based on four major test programs: lubricant compatibility with oxygen-rich environment for crew-compartment toxicity-order hazard evaluations; lubricant-propellant compatibility investigations for long-exposure endurance; solid-dry-film lubricant compatibility with various anodic coatings; and studies of lubricant sliding-friction behavior in vacuums such as are encountered in space. These tests resulted in the selection of several solid-dry-film lubricants, such as a completely inorganic, electrophoretic, bonded material containing molybdenum disulfide, graphite, and lead sulfide as the major lubricity. Among the greases, a completely polymeric perfluorinated material with a fluorocarbon-telomer thickener showed an unsurpassed compatibility with propellants and, in the oxygen-compatibility tests, a remarkable inertness. Author

**N66-28244#** Argentina. Comision Nacional de Energia Atomica, Buenos Aires.

**RADIOACTIVE TRACERS IN THE STUDY OF THE WEAR OF HARD NICKEL ALLOY BALLS [TRAZADORES RADIOACTIVOS EN EL ESTUDIO DEL DESGASTE DE BOLAS DE ALEACION NI-HARD]**

Mario Pio Gomez, Basilio Rapaport, and Walssee de Rea 1966 32 p refs In SPANISH

(CNEA-187) CFSTI: HC \$2.00/MF \$0.50

This study was conducted to demonstrate the wear resistance of chromium-nickel-iron alloy grinding balls used in the fabrication of cement. Cobalt 60, added to the iron melt prior to alloying, was used as a tracer to measure the amount of wear on the grinding balls. The tracer dissolves easily in the melt and its distribution is uniform in the balls. The recovery of the labelled balls is easily accomplished as the doses used are low enough so that there is no radiation danger. There was no evidence of fracture in the specimens used. It was verified that the alloy's resistance to abrasion was increased with the percentage of martensite which also increased its hardness. The wear resistance of the chromium-nickel-iron alloy balls is considerably greater than that of conventional steel balls.

Transl. by R.N.A.

**N66-28246#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE CHANGE OF PROPERTIES OF DISPERSION MEDIA OF PLASTIC LUBRICANTS UNDER THE EFFECT OF RADIATION**

Ye. D. Makeyeva, L. A. Kumleva et al 23 Mar. 1966 9 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 9, 1964 p 38-40

(FTD-TT-65-1731/1+4; AD-631448) CFSTI: HC \$1.00/MF \$0.50

The change in properties of a series of oils, used in role of dispersion media of plastic lubrications, under the effect of gamma-radiation was investigated. The anti-radiation properties on these oils of admixture of two types were determined: binding free radicals (e.g. dialkylselenides) and absorbing radiation energy on account of resonance adsorption in the molecules of condensed aromatic compounds (for example, acenaphthene).

TAB

**N66-28277#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PREPARATION OF LOW-FREEZING-POINT OILS BY DEPARAFFINING WITH CARBAMIDE**

M. G. Mitrofanov and O. A. Artem'yeva 23 Mar. 1966 9 p Transl. into ENGLISH from the publ. "Uluchsheniye Kachestva i Sovershenstvovaniye Proizvodstva Smazochnykh Masel" Moscow, Gostoptekhzdat., 1963 p 173-176

(FTD-TT-65-1509/1+4; AD-631449) CFSTI: HC \$1.10/MF \$0.50

Results are described of studies concerning the preparation of low-freezing-point transformer and spindle oils by extracting paraffins from various petroleum distillates with carbamide.

TAB

**N66-28337#** Atomic Energy of Canada, Ltd., Chalk River (Ontario).

**THE USE OF AMMONIA TO SUPPRESS OXYGEN PRODUCTION AND CORROSION IN BOILING-WATER REACTORS**

J. E. Le Surf, P. E. C. Bryant, and M. C. Tanner Apr. 1966 18 p refs Presented at the 22d Ann. Conf. of Natl. Assoc. of Corrosion Engr., Miami Beach, Fla., Apr. 1966 (AECL-2562) CFSTI: HC \$1.00/MF \$0.50

Radiolysis of the coolant in nuclear reactors cooled by boiling water results in oxygen in the steam and recirculated water phases. This has dictated the use of stainless

steels as the major circuit materials for these reactors. It is shown that ammonia additions to the coolant eliminate oxygen production, permitting the use of mild steel for circuit construction with consequent savings in capital cost. Corrosion data are presented for various out-reactor materials (carbon steel, low alloy steels, stainless steels, Monel alloy 400, Inconel alloy 600) exposed to the coolant of two phase in-reactor loops when operated neutral and with ammonia addition. The elevation in pH resulting from ammonia addition is a further advantage for low temperature parts of the circuit. Author

**N66-28339#** Metaalinstituut TNO, Delft (Netherlands). **COMPARATIVE RESEARCH OF NINE SAMPLES OF CARBON REMOVERS [VERGELIJKEND ONDERZOEK VAN NEGEN MONSTERS ONTKOLINGSMIDDEL]** L. M. Rientsma 18 Feb. 1966 10 p In DUTCH (C66-155; TDCK-45012) CFSTI: HC \$1.00/MF \$0.50

Comparative tests were conducted on several carbon removers to evaluate their efficiency for use in clogged oil pumps. Among the criteria considered were the boiling and firing points, solubility, appearance, emulsifying properties, corrosion effect, oil removing and cleaning properties, ease of rinsing, and poison content. Copper, steel, and aluminum plates, heat treated at 175°C, were used in the investigations. Tabulated data are included to show the results for each product tested. Transl. by J.O.

**N66-28345#** Bureau of Mines, Bartlesville, Okla. Bartlesville Petroleum Research Center. **SYNTHESIS OF ALKYL CYCLOALKYL AND DICYCLOALKYL SULFIDES** R. W. Higgins, R. L. Hopkins, H. J. Coleman, C. J. Thompson, and H. T. Rall (Tex. Woman's Univ.) 1966 20 p refs (BM-RI-6796)

Fifteen alkyl cycloalkyl sulfides and three dicycloalkyl sulfides were synthesized to provide reference compounds in the search for these classes of sulfur compounds in crude oils. In synthesizing sulfides by alkaline alkylation the order in which the reactants were added was shown to determine the yield and purity of the product. Author

**N66-28357#** Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div. **REACTOR FUELS AND MATERIALS DEVELOPMENT FOR FY 1965 Annual Progress Report** W. C. Francis, ed. Feb. 1966 138 p refs (Contract AT(10-1)-205) (IDO-17154) CFSTI: HC \$4.00/MF \$1.00

Progress is reported on developments in the uranium intermetallic fuel systems and on corrosion properties of several aluminum and aluminum-beryllium alloys. Microprobe examinations on irradiated and unirradiated fuel materials located fission products in fuel particles and matrix and were extremely helpful in evaluating fuel-matrix and fuel-cladding compatibility. The results of compression, impact and gas release measurements on beryllium irradiated at reactor ambient and at high temperatures are reported and compared with fractography studies. Fatigue studies on pressure vessel steels are summarized and the status is given on construction of an in-pile fatigue loop. The results are given of ultrasonic and metallographic examinations of a Fiberglass-fueled, aluminum-clad MTR fuel element. Developments in nondestructive testing, electron microscopy, fuel failure mechanisms, stress analysis, and prototypical irradiations are also reported. Author (NSA)

**N66-28679#** General Electric Co., Schenectady, N. Y. Research and Development Center. **HOT CORROSION MECHANISM STUDIES Final Report** 15 Feb. 1966 121 p refs (Contract N600(61533)63219) (AD-629598) CFSTI: HC \$4.00/MF \$0.75

#### CONTENTS:

1. THE ROLE OF SODIUM SULFATE IN THE ACCELERATED OXIDATION OF NICKEL J. R. Gambino 41 p refs (See N66-28680 16-17)
2. OBSERVATIONS ON THE HIGH-TEMPERATURE SULFUR-OXYGEN CORROSION OF NICKEL A. U. Seybolt 18 p refs (See N66-28681 16-17)
3. THE BEHAVIOR OF COBALT IN HIGH-TEMPERATURE SULFUR-OXYGEN CORROSION OF NICKEL A. U. Seybolt 18 p refs (See N66-28681 16-17)
4. HOT CORROSION BEHAVIOR OF NICKEL AND COBALT BINARY AND TERNARY ALLOYS P. A. Bergman 32 p ref (See N66-28683 16-17)

**N66-28680#** General Electric Co., Schenectady, N. Y. **THE ROLE OF SODIUM SULFATE IN THE ACCELERATED OXIDATION OF NICKEL** J. R. Gambino Jan. 1966 *In its* Hot Corrosion Mech. Studies 15 Feb. 1966 41 p refs (See N66-28679 16-17) CFSTI: HC \$4.00/MF \$0.75

Thermogravimetric monitor methods of high temperature nickel oxidation by sodium sulfate showed that nickel oxidized initially: (1) independent of sodium sulfate concentrations; (2) dependent upon oxygen pressure; (3) dependent upon temperature; and (4) dependent upon the moisture content of the oxygen environment. High initial nickel oxidation rates in the presence of small sodium sulfate amounts were somewhat delayed when oxide films formed on the nickel specimens prior to sulfidation attack; in all cases vigorous corrosion occurred eventually. Correlation between the amount of nickel oxidation and the amount of sodium sulfate indicated sulfur expenditure during oxidation. G.G.

**N66-28681#** General Electric Co., Schenectady, N. Y. **OBSERVATIONS ON THE HIGH-TEMPERATURE SULFUR-OXYGEN CORROSION OF NICKEL** A. U. Seybolt Jan. 1966 *In its* Hot Corrosion Mech. Studies 15 Feb. 1966 18 p refs (See N66-28679 16-17) CFSTI: HC \$4.00/MF \$0.75

Sodium sulfate corrosion of nickel and nickel alloys largely concentrated at the grain boundaries; at high temperatures and enough available sulfur concentrations molten nickel-nickel sulfide eutectic compositions developed. Gas turbine alloys containing chromium eroded by forming CrS as the principal sulfide; low melting  $\text{Ni}_3\text{S}_2$ -Ni eutectic or  $\text{Co}_4\text{S}_3$ -Co eutectic did not develop in larger quantities as long as unreacted chromium was present. G.G.

**N66-28682#** General Electric Co., Schenectady, N. Y. **THE BEHAVIOR OF COBALT IN HIGH-TEMPERATURE SULFUR-OXYGEN ENVIRONMENTS** A. Beltran and A. U. Seybolt Jan. 1966 *In its* Hot Corrosion Mech. Studies 15 Feb. 1966 11 p refs (See N66-28679 16-17) CFSTI: HC \$4.00/MF \$0.75

Exposure of cobalt and cobalt-chromium alloys to  $\text{Na}_2\text{SO}_4$  under an oxidizing atmosphere showed a reduction of the salt followed by sulfide formation. Liquid Co- $\text{Co}_4\text{S}_3$  eutectic (above 877°C) formed in the case of pure cobalt, and CrS developed in the presence of chromium; the rapid corrosive attack of the metal structure occurred by oxidation of the sulfide. It was concluded that optimal amounts of chromium in commercial gas turbine cobalt-base alloys

form an adherent  $\text{Cr}_2\text{O}_3$  surface oxide and thus assist in blocking sulfur penetration; this method can also prevent formation of the liquid sulfide eutectic. G.T.

**N66-28683# General Electric Co., Lynn, Mass.  
HOT CORROSIVE BEHAVIOR OF NICKEL AND COBALT  
BINARY AND TERNARY ALLOYS**

P. A. Bergman Jan. 1966 *In its Hot Corrosive Mech. Studies* 15 Feb. 1966 32 p ref (See N66-28679 16-17) CFSTI: HC \$4.00/MF \$0.75

Nickel and cobalt and their binary and ternary alloys were studied for their hot corrosion behavior by exposure to combustion products of sulfur enriched (1%) diesel fuel, and a high concentration of sea salt (200 ppm) for 100 hours at 1675°, 1750°, and 1900°F. Metallographic and X-ray diffraction analyses of the exposed specimens found chromium additions to nickel and cobalt beneficial. Cobalt and titanium in nickel alloys, and nickel and tantalum in cobalt alloys did not effect the corrosive process significantly. Tungsten, molybdenum, and aluminum in nickel alloys and tungsten and molybdenum in cobalt alloys increased sulfur corrosion effects under high temperature conditions. In general, cobalt alloys showed more sulfur attack resistance than nickel alloys; nickel, cobalt, and chromium-rich spinels proved as much corrosion protective as  $\text{Cr}_2\text{O}_3$ . G.G.

**N66-28854# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.**

**PLASTICS Selected Articles**

18 Jun. 1965 25 p refs Transl. into ENGLISH from *Plasticheskiye Massy* (Moscow), no. 8, 1964 p 20-23; 31-33 (FTD-TT-65-319/1+2+4; TT-65-63105; AD-619482) CFSTI: HC \$1.00/MF \$0.50

**CONTENTS:**

1. STRENGTH OF GLASS PLASTICS AND ITS DEPENDENCE UPON THE CHANGE IN WETTING ANGLE WITH BINDING OF WATERPROOFED GLASS FIBERS Ye. B. Trostyan-skaya, A. M. Poymanov, and Yu. N. Kazanskiy p 1-11 refs (See N66-28855 16-18)

2. MECHANICAL AND FRICTION PROPERTIES OF POLYAMIDE AND POLYETHYLENE COATINGS A. A. Kut'kov and D. T. Avdeyev p 12-17 refs (See N66-28856 16-18)

**N66-28856# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.**

**MECHANICAL AND FRICTION PROPERTIES OF POLYAMIDE AND POLYETHYLENE COATINGS**

A. A. Kut'kov and D. T. Avdeyev *In its Plastics* 18 Jun. 1965 p 12-17 refs (See N66-28854 16-18) CFSTI: HC \$1.00/MF \$0.50

The dependence of mechanical strength and friction resistance of polyamide and polyethylene coatings upon the method of application and cooling was investigated. The coatings were tested for shear, bending, and impact strengths, and wear resistance. Gas flame dusting and vortex dusting were used, and the cooling was in open air, water at room temperature, and oil at 180°C. Among the conclusions are: (1) The vortex dusting method assures much higher adhesion of the film to metal, offers much higher and more stable strength values of the film at shear, bending, and impact load than gas flame dusting. (2) Thermal processing changes the structure of polyamide coating; and films cooled in water have an amorphous structure, are more elastic and remain intact at greater deformation. (3) Polyethylene coatings are recommended for machine parts absorbing shock loads, but are unsuitable under deformations. (4) Polyamide coatings can be used for antifriction coatings at small loads. (5) With increase in load the friction coefficient of polyamide on steel

decreases, but also the stability of the friction moment decreases considerably. N.E.N.

**N66-28939# Pratt and Whitney Aircraft, Middletown, Conn.  
CORROSION STUDIES OF REFRACTORY METAL ALLOYS  
IN BOILING POTASSIUM AND LIQUID NaK**

K. J. Kelly, S. S. Blecherman, and J. E. Hodel 22 Apr. 1965 22 p refs Presented at the AEC-NASA Liquid Metals Information Meeting, Oak Ridge, Tenn. (Contract AT(30-1)-2789)

(CNLM-6246; CONF-650434-1) CFSTI: HC \$1.00/MF \$0.50

Compatibility evaluations were made in gravity-feed potassium loops at temperatures up to 2000°F on the following materials: Nb-1 Zr, PWC-533 (C-Mo-Nb-Ti-Zr), PWC-11 (C-Nb-Zr), Type 316 stainless steel, and Mo-TZM. The evaluations were based on weight changes, chemical analyses, metallographic examinations, and mechanical strengths. A study was also made of interactions of Nb-1 Zr specimens in a Type 316 stainless steel-eutectic NaK loop operated at 1250°F. NSA

**N66-28987# Virginia Polytechnic Inst., Blacksburg Dept. of Metals and Ceramic Engineering.**

**THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION**

Quarterly Report No. 438-6, Oct. 1-Dec. 31, 1965 B. N. Ferry and J. F. Eckel Jan. 1965 17 p refs (Contract AT(40-1)-3208)

(EURAC-1579) CFSTI: HC \$1.00/MF \$0.50

A  $\text{N}_2$  concentration range of 0.06 to 0.09 % was obtained in wires of type 304 stainless steel by nitriding in different ratios of  $\text{H}_2$ - $\text{NH}_3$  at 1000°F for 24 hr. Nitrides were not metallographically observed in any of the wires. A dilatometer specimen holder was built and calibrated. Author

**N66-29157# Rock Island Arsenal Lab., Ill.  
GALVANIC SERIES OF METALS AS RELATED TO CORROSION**

Ervin C. Tinsley Feb. 1966 22 p refs (RIA-66-469; AD-631962) CFSTI: HC \$1.00/MF \$0.50

A revised electromotive series has been prepared for use by design engineers. Tables were prepared from experimental data and from available literature references. The experimental work indicated many variables were present in the half-cell potential measurement procedure. Many factors that could have caused deviations in results are discussed. This work provides information as to the location of various alloys previously not included in the electromotive series. The use of the improved table will be of value to the designer for his selection of compatible materials, and enable him to hold the possibilities of galvanic corrosion to a minimum. Author (TAB)

**N66-29292# General Dynamics/Convair, San Diego, Calif.  
CENTAUR TANK CORROSION TESTS AND X-RAYS**

1 Aug. 1965 147 p refs (Contract NAS3-3232) (NASA-CR-72000; GD/C-BNZ-65-032) CFSTI: HC \$4.00/MF \$1.00 CSCL 20K

It is found that tank corrosion can be deterred or prevented by the following method: (1) elimination of the corrosive elements from the tank fabrication processes; (2) fabrication of the tank under stringently clean conditions, and the providing of protection from contamination during storage; and (3) the application of a corrosion inhibitor to the outside surfaces of the tank structure and to the parts and assemblies as early in the fabrication process as is compatible with manufacturing operations. The effectiveness of these measures was demonstrated by the low quantity of corrosion found on Centaur tanks 7D, 8D, and 9D. Author

**N66-29401\*** National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

**SALT STRESS CORROSION OF Ti-8Al-1Mo-1V ALLOY SHEET AT ELEVATED TEMPERATURES**

G. J. Heimerl, D. N. Braski, D. M. Royster, and H. B. Dexter [1965] 28 p refs Presented at the 5th Pacific Area Natl. Meeting of the Am. Soc. for Testing and Mater., Seattle, 31 Oct.-5 Nov. 1965 /Its Paper No. 42

(NASA-TM-X-56881) CFSTI: HC \$2.00/MF \$0.50 CSCL 11F

In the investigation of the salt stress corrosion of Ti-8Al-1Mo-1V alloy sheet, many small self-stressed and residual stress specimens were salt coated, exposed up to 6400 hours at 400°F to 600°F (477°K to 589°K), and tested at room temperature to determine the extent of the stress corrosion cracking. Coatings of NaCl were more corrosive than  $\text{CaCl}_2$ ,  $\text{MgCl}_2$ , or sea salt, and thin coatings were more damaging than thick. Environmental tests showed that a decrease in oxygen and air pressure reduced stress corrosion, but that the role of moisture and air velocity still remained in doubt. Stress corrosion cracks were intergranular, and a correlation was obtained between the results of the room-temperature corrosion tests and the crack penetration.  $\text{TiCl}_2$  appeared to be one of the corrosion products. Surface treatments such as shot peening, nickel plating, vibratory cleaning, and polyimide coatings proved effective in preventing corrosion for exposures up to 2000 hours at 600°F.

Author

**N66-29548#** Aerojet-General Corp., Sacramento, Calif. REON Div.

**METALLURGICAL INVESTIGATION OF HYDROGEN PRE-HEATER TUBE FAILURE**

D. J. Lamuermyer Mar. 1966 38 p refs (RN-TM-0312)

An investigation was conducted to determine (a) the cause of gaseous hydrogen preheater tube failure, (b) extent of damage from overheating, and (c) actions necessary to qualify the preheater for operation. The primary fracture was caused by zinc contamination, which penetrated the grain boundaries under elevated temperature conditions. Cracks were progressively formed causing reduction of tube wall thickness and rupture. Overheating damage was indicated by measuring the OD of all tubes, and revealed that tubes numbered 31 through 40 and 99 in the north arch were bulged. The remaining tubes were not adversely affected by the overheating as evidenced by satisfactory elevated and room temperature tensile, sensitization, degradation, and bulge test results. Recommendations were made to (a) inspect all tubes by shear-wave ultrasonic tests for detection of cracks prior to the initial test run and periodically thereafter, (b) proof and leak test and preheater at a pressure equivalent to one-half of the material yield strength, and (c) independently support the sine-wave spacers to prevent sagging during future heater operations.

Author

**N66-29690#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**NEW METHOD OF EVALUATING THE EFFECTIVENESS OF ACTION OF ANTI-SCORING ADMIXTURES TO OILS AND FUELS**

K. I. Klimov, A. V. Vilenkin, and G. I. Kichkin 23 Mar. 1966 15 p refs Transl. into ENGLISH from Tr. Vsesoyuznoye Nauchno-Tekhn. Soveshch. po Prisadkam k Maslam i Toplivam, 1960 (USSR), 1961 p 273-278 (FTD-TT-65-1491/1+2+4; AD-631838) CFSTI: HC \$1.00/MF \$0.50

To evaluate anti-scoring properties of lubricating materials an essentially new type of friction machine having a pair of intersecting cylinders and periodic surface contact was developed and proposed. The necessity of relative evaluation of anti-scoring properties of oils containing admixtures on

friction machines in order to model the testing conditions by the sliding rate, contact periodicity and temperature in a wide range of their changes is shown. A method was developed for the relative evaluation of anti-scoring properties of lubrication materials in conditions that model real conditions of oil operation. Anti-scoring properties of certain petroleum products in pure form, and with admixtures were investigated. It was shown that the proposed instrument and evaluation method have a high sensitivity in comparison with other methods and instruments.

Author (TAB)

**N66-29818#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**AN ADDITIVE FOR SUPPRESSING VANADIUM CORROSION OF FUELS**

R. A. Lipshteyn and A. S. Avetisyan 20 Sep. 1965 6 p Transl. into ENGLISH from Soviet Patent No. 162269 (Appl. No. 849707/23-4, 29 Jul. 1963) 1 p (FTD-TT-65-505/1+4; TT-65-64042; AD-621778) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is an additive for suppressing vanadium corrosion of fuels on the basis of green oil. For the purpose of improving the additive's properties tetraethoxysilane or the bottoms in the production of tetraethoxysilane is added to the green oil.

Author (TAB)

**N66-29866\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EFFECT OF ORIENTATION ON FRICTION CHARACTERISTICS OF SINGLE-CRYSTAL BERYLLIUM IN VACUUM (10<sup>-10</sup> TORR)**

Donald H. Buckley Washington, NASA, Jul. 1966 20 p refs (NASA-TN-D-3485) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

Studies were conducted to determine the influences of the crystallographic orientation of single-crystal beryllium on its friction characteristics when in sliding contact with sapphire and polycrystalline beryllium and aluminum oxide. Experiments were conducted in a vacuum of 10<sup>-10</sup> torr with a 3/16-inch hemispherical-radius beryllium crystal sliding on a flat of beryllium and aluminum oxide. The rider was loaded against the flat with various loads from 100 to 1500 grams and the flat disk was rotated to give a sliding speed of 0.013 centimeter per second. The results of the investigation showed that the basal plane exhibited lower friction than the prismatic slip plane. With the basal plane parallel to the interface, lower friction coefficients were observed in the  $\langle 11\bar{2}0 \rangle$  than in the  $\langle 10\bar{1}0 \rangle$  directions. The lowest friction coefficient for basal orientation was obtained with the basal plane inclined 135° to the sliding interface. The friction coefficient of single-crystal beryllium sliding on sapphire was lower than that of single-crystal beryllium sliding on polycrystalline aluminum oxide. With sapphire, brittle fracture of sapphire was observed, while with polycrystalline aluminum oxide, shear of beryllium was observed.

Author

**N66-29944#** SKF Industries, Inc., King of Prussia, Pa. Research Lab.

**A BASIC STUDY OF THE SLIDING CONTACTS IN ROLLER BEARINGS** Quarterly Progress Report No. 4, 16 Jan.-15 Apr. 1966

Chester J. Belsky, M. Cocks, and W. E. Schmidt [1966] 86 p refs

(Contract Now-65-0182-f)

(AL66L026; AD-632493) CFSTI: HC \$3.00/MF \$0.75

A study was made of the kinematics of a flat washer to roller test configuration.

Author (TAB)

**N66-29945#** Naval Air Engineering Center, Philadelphia, Pa. Aeronautical Materials Lab.

# **CHEMICAL MILLING OF ALLOY STEELS**

Sara J. Ketcham 9 Mar. 1966 22 p refs

(NAEC-AML-2418; AD-631952) CFSTI: HC \$1.00/MF \$0.50

Experiments were conducted to determine the effect of chemical milling on susceptibility of high strength steels to hydrogen embrittlement and stress corrosion cracking. Alloys studied included H-11, 4340 and 17-7 PH. Results indicated that the acid baths used for chemical milling do initially embrittle these alloys, but recovery of ductility takes place at room temperature within one week if there is no barrier to the escape of hydrogen (such as a plating). A recovery treatment of 48 hours at room temperature followed by 4 hours at 375°F is recommended. A high strength steel with a chem-milled surface is more susceptible to stress corrosion cracking than one with a machine ground surface.

Author (TAB)

**N66-30236#** Laboratoires du Centre d'Etude de l'Energie Nucleaire, Mol (Belgium).

# **IMPERFECTIONS IN METALS. II: CORROSION AND OXIDATION Quarterly Report No. 11, 1 Apr.-30 Jun. 1965**

Brussels, EURATOM, [1965] 24 p refs

(Contract EURATOM-054-64-4 TEEB)

(EURAC-1457; EUR-2386; R-2355) CFSTI: HC \$1.00/MF \$0.50

Transmission electron microscopy of corrosion-oxidation films formed on both Van Arkel zirconium and Zircalloy-2 in air from 250° to 450°C and in water from 225° to 325°C showed that gross differences existed in the film morphology depending on the environment and surface preparation. Annealed Zr, oxidized in air, formed monoclinic zirconia films which replicated the metal grain structure but which also contained fine-grain regions, pseudo-amorphous areas, pustules, and preferentially oxidized grain boundaries. Etched Zr, oxidized under the same conditions, formed uniform films having only one heterogeneity, viz. preferentially oxidized twins. Oxidation of annealed Zr in water produced a high density of oxide nuclei (monoclinic oxide) on a single crystal monoclinic matrix. Longer oxidation produced pustules which were much more numerous than those formed by air oxidation. Zircalloy-2 generally formed more uniform films than Zr in both air and water and did not exhibit the preferential grain boundary oxidation so prevalent in Zr oxidation films. Annealed Zircalloy-2 formed mottled films, whereas etched Zircalloy-2 oxidized similarly, showed unmottled grains which were sharply delineated and which clearly showed local areas corresponding to the intermetallics.

NSA

**N66-30272#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

# **TRANSACTIONS OF THE MOSCOW INSTITUTE OF PETRO-CHEMICAL AND GAS INDUSTRY [MOSKOVSKIY ORDENA TRUDOVOGO KRASNOGO ZNAMEINI INSTITUT] Selected Articles**

20 Jul. 1965 31 p refs Transl. into ENGLISH from the publ. "Petrochemistry. Processing of Oil and Gas" no. 28, Moscow, Gostoptekhizdat, 1960 p 44-55, 56-67

(FTD-MT-64-512; AD-619476) CFSTI: HC \$2.00/MF \$0.50

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**N66-30273#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

# **INFLUENCE OF CHEMICAL NATURE AND STRUCTURE OF HIGH-POLYMER ADDITIVES ON VISCOSITY PROPERTIES OF OILS OF DIFFERENT CHEMICAL COMPOSITION**

D. S. Velikovskiy and L. V. Chervova *In its* Trans. of the Moscow Inst. of Petrochem. and Gas Ind. 20 Jul. 1965 p 1-13 refs (See N66-30272 17-06) CFSTI: HC \$2.00/MF \$0.50

The viscosity properties of polymers of unsaturated hydrocarbons, and polymers of unsaturated esters or esters of unsaturated acids were investigated. These were polyisobutylene and polymethacrylates of normal and isostructure. The properties of the three oils tested, and the viscosity-temperature numbers of the oils with and without the additives, and with the additives in separate fractions are presented. Viscosity-temperature curves are also included. Among the conclusions are: (1) High polymer additives lead to sharp improvement of viscosity-temperature properties. (2) The chemical composition of the initial oils has little effect on the viscosity-temperature properties but does influence the viscosity. (3) The additives possess the least thickening effect in the naphthene-paraffin fractions of the oils, and polymethacrylates produce a larger thickening effect in the heavy aromatic fractions. (4) The thickening effect of the polymers is greater in the oils with small viscosity, and the thickening effect decreases with increase of temperature.

N.E.N.

**N66-30274#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

# **SYNTHESIS OF NEW ANTIOXIDANT ADDITIVES**

V. I. Isagulyants and N. A. Favorskaya *In its* Trans. of the Moscow Inst. of Petrochem. and Gas Ind. 20 Jul. 1965 p 14-26 refs (See N66-30272 17-06) CFSTI: HC \$2.00/MF \$0.50

The steps in the synthesis of bisphenol additives and their effectiveness in insulating oils and motor fuels are reviewed. The stages are identified as the alkylation of phenols of olefins in the presence of catalysts, and the condensation of alkylphenols with formaldehyde in the presence of hydrochloric acid. The synthesis of 2,2'-methylene-bis-(6-tert-butyl-4-methylphenol) and the synthesis of 2,2'-methylene-bis-(4,6-di-tert-butyl-3-methylphenol) are given as illustrations. It was found that the new additives are as effective as the standard in most cases, and exceed the standard in some. It was also concluded that the synthesized additives almost double the yield of antioxidant additives by utilizing a by-product in the production of the standard additive.

N.E.N.

**N66-30409#** Aerojet-General Nucleonics, San Ramon, Calif. **ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. STUDIES OF HASTELLOY X CORROSION IN AIR AT 1900 AND 2000°F**

J. S. Brunhouse Dec. 1965 31 p refs

(Contract AT(10-1)-880)

(AGN-TM-414) CFSTI: HC \$2.00/MF \$0.50

An evaluation of the corrosion resistance of Hastelloy X sheet and tubing materials at 1900° and 2000°F in air was undertaken to establish limiting oxidation rates and physical metallurgical changes in an effort to define the limiting lifetime/temperature characteristics of this material. Test specimens were to be exposed in air for 100, 1000, 2500, 5000, 7500, and 10,000 hr durations or until the time limitations were established. It appears that Hastelloy X would probably be useful as a fuel cladding for reasonably long periods of time in 1900°F air although specific limiting criteria need to be developed. At 2000°F, however, rapid oxidation and strength decreases would probably limit the service life of the material to a few thousand hours.

NSA

**N66-30414#** Battelle Memorial Inst., Columbus, Ohio. Columbus Labs.

**DEVELOPMENT OF THORIUM-U<sup>233</sup> IRRADIATION SPECIMENS**

Sidney G. Nelson and Ellis L. Foster, Jr. 10 Feb. 1966 24 p (Contract W-7405-ENG-92)  
(BMI-1761) CFSTI: HC \$0.50/MF \$0.50

Fabrication techniques were developed and employed in the preparation of irradiation and calibration samples to be used in a program designed to obtain equilibrium values of <sup>233</sup>U buildup in thorium in both fast and slow neutron-flux spectra. Twenty-two standard-calibration and 60 irradiation samples consisting principally of cores of thorium or thorium with additions of <sup>233</sup>U, gold, or boron surrounded by reactor-grade zirconium cladding metallurgically bonded to the core were prepared. All specimens were evaluated after their preparation. The results of fabrication, ultrasonic and autoclave (corrosion) testing of samples, and metallographic examination of core materials are discussed. Author (NSA)

**N66-30579#** Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.

**STRESS CORROSION IN ALLOYS FOR FUEL ELEMENT CLADDING—STAINLESS STEEL AND ZIRCALOY**

K. C. Thomas and R. J. Allio Sep. 1965 136 p refs (Contract AT(30-1)-3269)  
(WCAP-3269-50) CFSTI: HC \$4.00/MF \$1.00

Studies were made to determine the factors responsible for the stress corrosion failure of stainless steel and Zircaloy-4 fuel element cladding so that they can be controlled and the susceptibility to failure minimized. At room temperature, Zircaloy-4 and crystal bar zirconium were found to be susceptible to brittle failure when stressed at 30,000–50,000 psi (2,109–3,515 kg/cm<sup>2</sup>) in aqueous solutions of up to 20 wt % ferric chloride, having a pH of 0.6. The time of failure decreased with increases in stress, increase in chloride solution concentration, and increase in hydrogen content of the metal. The failures observed in zirconium alloys containing hydrogen are explained by a mechanism that involves the initiation of cracks in the hydride phase by piled-up groups of dislocations. Increase in strain at a given temperature, and increase in temperature at a given strain increased the dislocation density of 304 stainless steel and Incoloy 800. The time to failure of 304 stainless steel, in boiling magnesium chloride solution, at 40,000 psi was less than 1 hr, whereas failure did not occur in Incoloy 800 in less than 350 hr under similar conditions. NSA

**N66-30771#** Los Alamos Scientific Lab., N. Mex.

**CORROSION TEST OF HASTELLOY N, INCONEL 600, AND Hymu-80 EXPOSED TO UCl<sub>3</sub>-KCl AT 900°C**

B. J. Thamer 4 Feb. 1966 14 p refs (Contract W-7405-ENG-36)  
CFSTI: HC \$1.00/MF \$0.50

Static, isothermal tests up to 84 days in length were performed in the UCl<sub>3</sub>-KCl eutectic of the highest uranium concentration at 900°C. The maximum penetration in any case was approximately 2 mils. The corrosion was impeded by a metallic reaction layer, the composition of which was principally uranium and nickel. Author (NSA)

**N66-30970#** Pennsylvania State Univ., University Park. Mineral Industries Experiment Station.

**THE STRESS CORROSION SUSCEPTIBILITY OF HIGH STRENGTH STEELS Final Report**

John H. Hoke Jun. 1965 65 p (Contract AT(30-1)-3257)  
(NYO-3257-1) CFSTI: HC \$3.00/MF \$0.75

A study was made of stress-hydrogen cracking problems for type 410 stainless steel. The results show that a general correlation exists between resistance to stress hydrogen cracking and notch sensitivity. However, considerable variability in behavior is possible in apparently similar materials and direct conversion of impact data to stress-hydrogen cracking susceptibility is not reliable. Thermal treatments which increase fracture toughness also increase resistance to stress-hydrogen cracking. High-purity vacuum-melted alloys have much higher resistance to stress hydrogen cracking than commercial air-melted alloys. The specific ingredients present responsible for such degradation are not known, but general steel making alloy additions may contribute in part. NSA

**N66-30971#** Oak Ridge National Lab., Tenn.

**SNAP-8 CORROSION PROGRAM Quarterly Progress Report, Period Ending May 31, 1965**

H. W. Savage, E. L. Compere, R. E. Mac Pherson, W. R. Huntley, and A. Taboada Sep. 1965 22 p refs (NASA Order C-220-A, Contract W-7405-ENG-26)  
(NASA-CR-76382, ORNL-3859) CFSTI: HC \$2.00/MF \$0.50 CSCI 18N

Operation of the final loop (14-4) in the present phase of the corrosion program with continuous cold trapping and deuterium injection was completed. The objectives were to ascertain differences in corrosion and mass transfer rates resulting from continuous cold trapping and to evaluate the effectiveness of cold trapping in reducing the H<sub>2</sub> concentration in the NaK and thus the H<sub>2</sub> effluent from the loop. The loop operated for 2659 hr at design temperature prior to shutdown. The hydride trap for collecting extraneous H<sub>2</sub> operated for 500 hr, and the deuterium trap operated for 676 hr. The introduction of deuterium into the loop successfully served to distinguish between extraneous H<sub>2</sub> and that injected into the loop. The deuterium data indicated that the equilibrium pressure in the loop is approximately the same as the calculated H<sub>2</sub> partial pressure for the SNAP-8 primary system in space (2.4 × 10<sup>-5</sup> atm). Results of analytical examinations on all but loop 14-4 generally confirmed previous observations. Very little metal migration occurred in low-O<sub>2</sub> content NaK at both temperature levels investigated; however, C migration was severe. Corrosion of the Fe-base alloys in the low-O<sub>2</sub> content NaK was very low, as compared with corrosion of the chromized Hastelloy N, which ranged from three to seven times as great. Sheet tensile specimens of Croloy 9M were decarburized to a C content of approximately 0.002 to 0.01%. As shown previously, there was general deterioration of mechanical properties. NSA

**N66-31045#** Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu.

**RADIATION RESISTANCE OF NaNO<sub>2</sub> SOLUTION USED TO INHIBIT CORROSION OF STEEL IN WATER [RADI-ACNI ODOLNOST ROZTOKU DUSITANU SODNEHO JAKO INHIBITORU VODNI KOROZE OCELI]**

V. Zajic and V. Rypar 1965 26 p refs In CZECHOSLOVAKIAN (UJV-1453/65)

The radiation resistance of aqueous sodium nitrite, used to inhibit the corrosion of steel in solution, was studied in the VVR-S research reactor. After 50 hr in the reactor the sodium nitrite concentration of the solution decreased to a constant level and remained at that level for another one-hundred hours. The constant level depended on the initial concentration, but was always sufficient to inhibit corrosion (i.e., greater than 1 g/liter) when the initial concentration was greater than 7 g/liter. In some cases there was a slight regeneration of nitrite, with the NaNO<sub>2</sub> concentration rising slightly after reaching a minimum value. For the VVR-S

fluxes the radiation intensity had little effect on the results. The volume of the solution likewise was not significant. The nature of the gas phase affected the results somewhat, with hydrogen and oxygen being better than nitrogen in protecting the sodium nitrite from the irradiation. NSA

**N66-31065#** Rocky Flats Div., Dow Chemical Co., Golden, Colo.

**THE CORROSION OF UNALLOYED AND ALLOYED PLUTONIUM IN MONOBROMOBENZENE AND FREON-113 FLUOROCARBON**

M. R. Dringman 14 May 1965 5 p

(Contract AT(29-1)-1106)

(RFP-744) CFSTI: HC \$1.00/MF \$0.50

The specimens were exposed for 26, 72, and 140 hr at 25°C. For the 26-hr period, monobromobenzene was 2.5 times more corrosive to the unalloyed Pu and 2 times more corrosive to the Pu-1 Ga alloy than the Freon-113. NSA

**N66-31070#** Oak Ridge National Lab., Tenn.

**A STUDY OF LEAD AND LEAD-SALT CORROSION IN THERMAL-CONVECTION LOOPS**

G. M. Tolson and A. Taboada Apr. 1966 18 p refs

(Contract W-7405-ENG-26)

(ORNL-TM-1437) CFSTI: HC \$1.00/MF \$0.05

Thermal-convection loop tests of several structural alloys were operated using circulating molten Pb. Screening tests were run to evaluate Croloy 2-1/4, ASTM-A106 carbon steel, AISI-type 410 stainless steel, and Nb-1%Zr. Two of the test loops contained surge tanks in which fluoride salts, Nb-1% Zr alloy, and graphite were placed in contact with the Pb to determine the compatibility of these materials in a direct-cooled lead system. All of the steel loops tended to plug in the cold regions because of formation of dendritic crystals of Fe and Cr. The hot-leg attack consisted of general surface removal with a few large pits extending to a greater depth. The Nb-1% Zr alloy showed no measurable attack; however, Nb crystals were found in the cold leg of a loop which operated 5000 hr at 1400°F with a  $\Delta T$  of 400°F. Author (NSA)

**N66-31092#** Ohio State Univ. Research Foundation, Columbus.

**MICROTOPOLOGY OF STRESS CORROSION CRACKING**

T. J. Smith and R. W. Staehle Mar. 1966 14 p refs Presented at the 3d Intern. Conf. on Metallic Corrosion, Moscow, May 1966

(Contract AT(11-1)-1319)

(COO-1319-36; CONF-660514-1) CFSTI: HC \$1.00/MF \$0.50

Thin films of four iron-nickel-chromium base alloys were examined in the electron microscope, exposed to boiling  $MgCl_2$ , and examined again. Compositions were as follows (atomic per cent): Fe-15Ni-20Cr, Fe-15Ni-20Cr-1.5Si, Fe-15Ni-20Cr-0.1N, Fe-45Ni-20Cr. Each alloy was treated to obtain structures in the annealed, strained, and aged condition. Examination of specimens exposed to boiling  $MgCl_2$  showed that stress exerts an important influence on the mode of cracking. In the absence of stress, attack tended to take the form of pitting; whereas, with stress the attack was highly oriented with the pitting being aligned in parallel crystallographic directions. The alloy containing phosphorus exhibited pitting having definite geometric shapes. Defect structure in the thin films appeared to have little correlation with established trends in cracking susceptibility nor with the mode of dissolution of thin films. Author (NSA)

**N66-31108#** Southwest Research Inst., San Antonio, Tex.  
**LUBRICATION RESEARCH FOR AERO PROPULSION SYSTEMS** Phase Report No. 1, 1 Feb.-1 Sep. 1965

E. L. Anderson, B. B. Baber, and P. M. Ku Oct. 1965 42 p (Contract AF33(615)-2384)

(AFAPL-TR-65-118; AD-625485) CFSTI: HC \$2.00/MF \$0.50

Investigations were conducted to determine the possible effect of selected aircraft gas turbine engine lubricants and various solvents on the removal of carbonaceous deposits which had accumulated during service on the No. 2 bearing rear support of the J-57 engine. Six MIL-L-7808 type and one MIL-L-23699 type lubricants and six solvents were included in this program. Under the test procedures used, the deposits on the bearing support specimens were found to be quite stable in the presence of all seven lubricants investigated; no loosening or sloughing of the deposits was observed. Of the six solvents evaluated, only Cities Service 26 was found to be effective in removing significant amounts of deposits from the specimen. Flashing of liquid water, which had penetrated the deposit covered surface, loosened crinkled, blistered, and flaked deposits, but had no effect on smooth carbon or varnish. Author (TAB)

**N66-31111#** Ampex Corp., Redwood City, Calif.

**INTERACTION BETWEEN SELF-ACTING AND EXTERNALLY PRESSURIZED EFFECTS IN A FOIL BEARING**

Edward J. Barlow Oct. 1965 24 p refs

(Contract Nonr-3815(00)(X))

(RR-65-12; AD-625762) CFSTI: HC \$1.00/MF \$0.50

For a foil bearing, the interaction between the flow of lubricant from feed holes and the flow in from the surrounding environment is calculated numerically. The results are applicable for a partial arc foil bearing whenever the feed holes are far from both ends of the warp angle. The report extends the linearized solution into the nonlinear range. Author (TAB)

**N66-31169#** Titanium Metals Corp. of America, New York.

**DEVELOPMENT OF A STABLE-BETA TITANIUM ALLOY**  
**Tenth Quarter Report, 1 Oct.-31 Dec. 1964**

D. B. Hunter [1964] 28 p refs

(Contract DA-30-069-ORD-3743)

(WAL-TR-405/2-9; AD-623600) CFSTI: HC \$1.00/MF \$0.50

Evaluation of ageable beta alloys Ti-17V-2Fe-2Co-3Al, Ti-17V-7.5Co-3Al and Ti-8Mo-8V-5Co-3Al continued with room and elevated temperature smooth and notched tensile tests, creep stability, oxidation and stress-corrosion tests. Ti-17V-7.5Co-3Al aged more rapidly than Ti-8Mo-8V-5Co-3Al; after aging for 8 hours at 900°F, Ti-17V-7.5Co-3Al had a yield strength of 198,000 psi, whereas that of Ti-8Mo-8V-5Co-3Al was only 158,000 psi. In smooth and notched tensile tests at 600°F, Ti-17V-7.5 Co-3Al displayed more strength than Ti-8Mo-8V-5Co-3Al because of its faster aging response in a given time. However, in creep stability tests and oxidation tests, Ti-8Mo-8V-5Co-3Al was the better alloy. Stress corrosion tests performed upon all five ageable beta alloys developed in this project showed that, in the annealed condition, Ti-8Mo-8V-2Fe-3Al was the most resistant to stress corrosion and Ti-17V-7.5Co-3Al and Ti-8Mo-8V-5Co-3Al the most susceptible. Author (TAB)

**N66-31323#** Franklin Inst., Philadelphia, Pa. Research Labs.  
**AN ANALYTICAL AND EXPERIMENTAL STUDY OF THE STRUCTUREBORNE AND AIRBORNE VIBRATION OF ROLLING ELEMENT AND SLIDING SURFACE BEARINGS**  
**Final Report**

H. C. Rippel and J. H. Rumbarger 31 Mar. 1966 148 p refs (Contract NObs-77184)

(F-A2321; AD-633146) CFSTI: HC \$5.00/MF \$1.00

An analytical and experimental study was made of bearing noise and vibration generation and transmission. Presented herein is: summary of previously reported work, report

of most recent progress, conclusions drawn from all of the work accomplished, and recommendations for additional work. This final technical report coupled with the numerous periodic progress reports and special interim reports issued during the course of the program treats all aspects of the following three phases of effort: (a) analytical study of bearing noise and vibration generation and transmission, (b) design and construction of a test device to experimentally evaluate bearing structureborne and airborne vibration, and (c) experimental evaluation of bearing structureborne and airborne vibration. Author (TAB)

**N66-31332#** Naval Research Lab., Washington, D. C.  
**INVESTIGATION OF THE INTERGRANULAR CORROSION OF LEAD-ANTIMONY GRID ALLOYS** Interim Report  
 A. C. Simon 7 Apr 1966 28 p refs  
 (NRL-6387; AD-633078) CFSTI: HC \$2.00/MF \$0.50

Microscopic examination of grid sections that had been in service for periods up to 10 years indicated that the ultimate cause of grid failure was an intergranular type of stress corrosion. While the overall corrosion resistance indicated the possibility of many additional years of service, this intergranular corrosion at isolated points had in many cases completely severed the grid member. It appeared that this corrosion was caused by a combination of stress developed in the corrosion product and microporosity in the casting. Two distinct corrosion mechanisms were observed. One type depended upon fairly acidic conditions, and the corrosion product was a hard film of lead dioxide which appeared to offer some protection to the underlying metal. The other type was generated where acid concentrations were low and was much more destructive. The corrosion product formed in this case varied from black to white and did not protect the underlying metal. Author (TAB)

**N66-31544#** Pennsylvania Univ., Philadelphia. Electrochemistry Lab.  
**HYDROGEN EMBRITTLEMENT RESULTING FROM CORROSION, CATHODIC PROTECTION AND ELECTROPLATING** Quarterly Report, Dec. 1965-Feb. 1966

E. Gileadi and M. Fullenwider 7 Mar. 1966 13 p refs  
 (Contract N156-46659)  
 (QR-3; AD-633402) CFSTI: HC \$1.00/MF \$0.50

The concentrations of hydrogen determined by the method of charging-up followed by pulling-out of hydrogen with the Barnacle Electrode were found to vary between  $2$  and  $6 \times 10^{-6}$  moles  $\text{cm}^{-3}$ , depending upon the conditions of polarization, these concentrations were calculated with an approximation, good for small times, the mathematics of which is outlined briefly. TAB

**N66-31686#** Mechanical Technology, Inc., Latham, N. Y.  
**APPROACHES TO THE MEASUREMENT OF THE STEADY STATE AND DYNAMIC PERFORMANCE CHARACTERISTICS OF LIQUID-METAL LUBRICATED BEARINGS**

E. B. Arwas, F. K. Orcutt, and B. Sternlight /in Argonne Natl. Lab. Proc. of the Conf. on Appl. of High Temp. Instrumentation to Liquid-Metal Expt. [1965] p 331-364 refs (See N66-31671 18-33) CFSTI: HC \$6.75/MF \$3.25  
 (Contracts NASw-771; NASw-1021; AT(30-1)-3363)

This paper presents a discussion of the instrumentation necessary for fundamental investigations, as well as for bearing development and for monitoring of bearing performance in turbomachinery. It points out through examples, that considerable advances applicable to liquid metal lubrication can be accomplished with easy to use fluids that simulate some of the important properties of liquid metals and making use of instrumentation that is already developed. Indirect meas-

urements which, in conjunction with accepted theoretical relations, provide meaningful interpretation of bearing performance are also discussed. Author

**N66-31864#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**MOLYBDENUM DISULFIDE-BASE SOLID LUBRICANTS**  
**Surveys of Foreign Scientific and Technical Literature**

Charles Blomberg 11 May 1966 15 p refs Transl into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 11, 1965 p 41-45  
 (ATD-66-52)

Since ordinary oils and greases cannot be used in these conditions of new technology, lubricants with new properties are now needed, i.e., solid lubricants. These are substances which possess a laminar structure and which ensure a sufficiently low friction coefficient between the coupled elements. Of the solid lubricants molybdenum disulfide, because of its special structure and a number of valuable properties, is finding increasingly wider application. The properties of molybdenum disulfide are discussed. The forms (powder, paste, solid lubricant coating and compact) in which solid lubricants can appear are listed and types which have been developed are enumerated. Paste concentrates are more convenient to use. Investigations are presented of the life and antifriction properties of solid film lubricants which are now industrially manufactured. The investigations were conducted in air, vacuum, and argon at extremely low temperatures and under radiation. The solid film lubricants which had the longest life are cited, as well as those in which the limit of working temperatures is increased to 500-600°C while in a vacuum of  $10^{-5}$  torr and in argon. It was concluded that exposure to low temperatures and radiation with an integrated dose of  $10^8$ - $10^9$  radiation does not shorten the life of solid film lubricants. Author

**N66-31918#** Royal Aircraft Establishment, Farnborough (England).

**FILLER REINFORCEMENT IN SILICONE POLYMERS. PART I: THE EFFECT OF FINELY DIVIDED MATERIALS ON LIQUID POLYMERS**

D. K. Thomas and B. B. Moore Feb. 1966 26 p refs  
 (RAE-TR-68061) CFSTI: HC \$2.00/MF \$0.50

The effect of finely divided materials on a polydimethyl silicone oil has been studied in the temperature range from 30° to 130°C using a variable shear viscometer. The results are consistent with the view that fine powders become solvated on being dispersed in the oil; if a sufficient number of particles are present per unit volume of mixture and if the interactions between them are sufficiently large, aggregation can occur to give a micro-gel structure. Those materials which are highly reinforcing in silicone elastomers show evidence of micro-gel structure at volume concentrations below 4%. For fillers of a given chemical type there are indications that the viscosity increment is dependent solely on mean particle size: there are further indications that carbon black is more effective in raising the viscosity than silica providing they are of comparable particle sizes. Author

**N66-32126#** Thompson Ramo Wooldridge, Inc., Cleveland, Ohio. TRW Electromechanical Div.

**MERCURY RANKINE POWER CONVERSION PROGRAM: MERCURY MATERIALS EVALUATION AND SELECTION**  
**GFY 1964 Topical Report No. 29**

James F. Nejedlik May 1965 53 p refs Prepared for Atomics International  
 (NAA-SR-6321; TRW-ER-6265) Available from AEC, Oak Ridge, Tenn.: \$3.45  
 (Declassified)



Reflux capsule corrosion screening tests were made of several nickel-, cobalt-, and iron-base alloys at 400-900°F. Classifications were made for use of these materials in a mercury environment on the basis of weight changes and penetration. Metal capsule tests at 800-1200°F indicated diffusion controlled corrosion for Haynes Alloy 25, PH15-7Mo and Croloy 9M. Weight losses and penetrations generally ranged on the average about four-fold greater than corresponding glass reflux capsule results. A thermal convection two-phase Haynes Alloy 25/PH15-7Mo loop which duplicated an earlier test substantiated corrosion data obtained previously. This showed that corrosion obtained in loop tests is reproducible. Inhibition of corrosion in a Haynes Alloy 25 loop was shown to be feasible. This was accomplished by two methods: a titanium-magnesium pretreatment; and a titanium source in a cold leg. Materials corrosion test results indicate a one-year life capability for the present MRPC reference materials. Author

**N66-32137\*** # Sherwin-Williams Co., Cleveland, Ohio.

**DEVELOPMENT OF IMPROVED CONVERSION COATING FOR USE WITH CORROSION-INHIBITING WHITE PRIMER**  
**Final Technical Report, 1 Mar.-15 Sep. 1965**

Charles R. Martens and Roger S. Downing 6 Jun. 1966  
 16 p refs

(Contract NAS8-11788)

(NASA-CR-76638) CFSTI: HC \$1.00/MF \$0.50 CSCL 11F

An improved chromate conversion coating was developed to increase the corrosion resistance in a white paint primer, and to withstand testing in a salt spray atmosphere. Experimental results on preliminary data obtained were checked by a statistically designed experiment, and reinforced the conclusion that a suitable chemical pre-treatment of the aluminum alloy improves the performance of a subsequently applied chromate conversion coating. A salt spray life of 237 hours for the optimum coating schedule was predicted, which suggests the process described could be the means of satisfactorily protecting the alloy. R. LI.

**N66-32514#** Rensselaer Polytechnic Inst., Troy, N. Y. Corrosion Research Lab.

**PREDICTING THE INTERGRANULAR CORROSION OF AUSTENITIC STAINLESS STEELS**

W. D. France, Jr. and N. D. Greene Oct. 1965 29 p refs  
 Presented at 21st NACE Conf., St. Louis, 15-19 Mar. 1965  
 (Contract Nonr-591-17)

(TR-3; AD-624017) CFSTI: HC \$2.00/MF \$0.50

The precise environmental conditions necessary for the intergranular corrosion of austenitic stainless steels have been determined by potentiostatic methods. Intergranular corrosion of sensitized 18Cr-8Ni stainless steel only occurs in limited potential regions. These results have been used to develop a new method for rapidly predicting the intergranular corrosion tendencies of various sulfuric acid environments. It is also shown that sensitized stainless steels may be used in many media without the occurrence of intergranular attack. Author (TAB)

**N66-32538#** Lockheed Missiles and Space Co., Sunnyvale, Calif.

**LUBRICATION EVALUATION**

Francis J. Clauss Apr. 1966 125 p refs

The performance of various types of lubricants on ball bearings operating in a simulated space environment was evaluated, including oils, greases, bonded films of solid lubricants, and composites of self-lubricating materials. The lubricants were evaluated on lightly loaded, instrument sized ball bearings operating at 8000 rpm. Simulated space conditions included vacuum to  $10^{-9}$  torr, temperatures up to 300°F,

and radiation doses up to  $4 \times 10^7$  R. General conclusions reached include: operation in vacuum can drastically reduce lubricant lifetime below that obtained for operation in air; oils and greases provide the best type of lubrication for ball bearings exposed to vacuum; ball bearing lifetime with oil lubrication increased with viscosity, which was most pronounced at low viscosities; bearing failures were preceded by lubricant failures; and ball bearings with retainers of reinforced Teflon operated successfully in vacuum for over 10,000 hr with light bearing loads. Tests were also conducted to evaluate the performance of various bonded solid film lubricants under conditions of sliding friction in air, and results were tabulated. The friction and adhesion of metals is also discussed, in reference to cold welding under vacuum conditions of space. L. E. W.

# 1965

## IAA ENTRIES

### A65-13892 #

#### SUPERCONDUCTIVE BEARINGS.

Theodor Buchhold (General Electric Co., Advanced Technology Laboratory, Schenectady, N.Y.).  
American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64 - WA/PID-9, 5 p.

Members, \$0.50; nonmembers, \$1.00.

Comparative study of two superconductive magnetic-bearing principles. The first principle keeps the total flux constant as current changes with a changing bearing gap. The leakage flux of the coil circuit limits the bearing stiffness. The second principle keeps the total ampere-turns constant when an additional fixed reluctance is inserted in the magnetic path. The bearing stiffness, which can be made large by using small gaps easily incorporated into the bearing design, is not seen to be influenced by the coil leakage.

(Author) M.L.

### A65-14065 #

#### LUBRICATION REVIEW.

(American Society of Mechanical Engineers, Winter Annual Meeting, Philadelphia, Pa., Nov. 17-22, 1964.)  
ASME, Transactions, Series D - Journal of Basic Engineering, vol. 86, Dec. 1964, p. 883-906, 461 refs.

Review of information in publications relating to several aspects of the field of lubrication, summarizing many of the results of current theoretical and experimental investigations. A list of 462 references is presented. Themes or patterns of current programs relating to lubrication are indicated. Each reviewer presents comments on the essential elements or results reported by the investigators. The areas reviewed include fluid-film lubrication, developments in lubricants, metalworking lubricants, automotive lubricants, gear lubrication, boundary lubrication, rolling element bearings, and friction and wear.

F.R.L.

### A65-14459

#### PREDICTING PART FAILURES.

Ray C. Johnson (Worcester Polytechnic Institute, Worcester, Mass.).

Machine Design, vol. 37, Jan. 7, 1965, p. 137-142, 20 refs.

Summary of certain conservative policies for predicting modes of failure and selecting reasonable values to be used in design equations. Criteria for the avoidance of fatigue breakage and excessive wear are presented under theories of failure for ductile and brittle materials. Correction factors for the fatigue strength in reversed bending and in shear are given. A table shows typical values of the ratio  $\gamma = S_{se}/S_e$  (where  $S_{se}$  is the shearing fatigue strength, corrected for surface finish, size, and miscellaneous effects, and  $S_e$  is the endurance limit from reversed bending tests of a ferrous metal, or the fatigue strength from reversed bending tests of a nonferrous metal for  $500 \times 10^6$  cycles, corrected for surface finish, size, and miscellaneous effects) and its inverse for a number of brittle cast irons and ductile steels, as calculated from the data of Sines and Waisman.

W.M.R.

### A65-14622

#### A STRESS CORROSION TEST FOR STRUCTURAL SHEET MATERIALS.

G. J. Heimerl and D. N. Braski (NASA, Langley Research Center, Hampton, Va.).

Materials Research and Standards, vol. 5, Jan. 1965, p. 18-22.

Discussion of a self-stressed sheet specimen (that does not require fixtures), developed for stress-corrosion testing of titanium-alloy and stainless-steel sheet materials proposed as skin materials for a supersonic transport. A compression test developed for early detection of stress-corrosion cracking is described, and some results obtained with salt-coated titanium-alloy sheet materials exposed to temperatures of 550°F over a period of 10,000 hrs are presented.

V.P.

### A65-14713 #

#### ON THE DETERMINATION OF STACKING FAULT ENERGIES IN AUSTENITIC STAINLESS STEEL BY THE METHOD OF EXTENDED NODE MEASUREMENTS.

A. Rönnquist and D. Dulieu (Swedish Institute for Metal Research, Stockholm, Sweden).

British Journal of Applied Physics, vol. 15, Dec. 1964, p. 1569-1571, 6 refs.

Investigation of the accuracy with which small changes in stacking fault energy may be detected. Extended nodes formed in two 18:11 austenitic steels were measured. From the high-purity steel the nodes have a mean radius of  $1600 \pm 350 \text{ \AA}$ . Addition of 0.2% P did not produce a significant change in the radius. A systematic correlation was found between the radius of the curved partial and its orientation in the slip plane.

(Author) F.R.L.

### A65-14748 #

#### MAGNETIC AND ELECTROSTATIC BEARINGS.

J. D. McHugh (General Electric Co., Advanced Technology Laboratories, Schenectady, N.Y.).

Mechanical Engineering, vol. 87, Jan. 1965, p. 45-48, 12 refs.

Review of bearings that rely on forces created by magnetic and electrostatic fields to provide load suspension in the absence of lubricants. Operation in vacuum and at extremes of temperature is thus readily afforded. Diamagnetic, magnetic, superconducting, and electrostatic bearings are discussed. As dictated by Earnshaw's theorem, a key problem in most of these systems is stability. Furthermore, the absence of solid contact or of fluid films between the surfaces does not ensure zero friction. Magnetic losses due to eddy currents and hysteresis are found to impede rotation just as conventional friction forces do, albeit somewhat more slowly. One estimate of the friction force in a well-designed magnetic-bearing suspension predicts that ten years of elapsed time is required for the system to coast down to 37% of its initial speed.

W.M.R.

### A65-14788

#### EFFECTS OF CONTACT FRICTION ON THE ENERGY CRITERIA FOR CYCLIC STRENGTH AND THE PHYSICAL FATIGUE LIMIT.

I. A. Odina and V. N. Stepanov.

(Akademiia Nauk SSSR, Doklady, vol. 156, June 21, 1964, p. 1333-1335.)

Soviet Physics - Doklady, vol. 9, Dec. 1964, p. 501, 502, 7 refs. Translation.

Discussion of contact friction as a factor influencing: (1) fatigue physical limit; and (2) cyclic-strength energy criteria  $\alpha$  and  $N_k$ , on the basis of which the fatigue destruction diagram is plotted. Tests with different types of steel show that contact friction significantly reduces the cyclic strength of the metal. A diagram of testing results is presented.

V. Z.

### A65-14875 #

#### THERMAL STABILITY OF ANTIWEAR ADDITIONS IN LUBRICATING OILS [TERMICHESKAYA STABIL'NOST' PROTIVOIZNOSNYKH PRISADOK V SMAZOCHEVNYKH MASLAKH].

A. M. Ravikovich, E. I. Petiakina, and P. P. Bagriantseva.

Khimiia i Tekhnologiiia Topliv i Masel, vol. 9, Dec. 1964, p. 44-47, 14 refs. In Russian.

Testing of the antiwear properties and thermal stability of: (1) 50% zinc dialkyl dithiophosphate (DF-11); (2) 50% zinc di-(alkylphenyl)-dithiophosphate with alkyls  $C_8$  to  $C_{12}$  from a propylene-butylene polymer (VNII NP-354); (3) zinc dialkyl dithiophosphate, an industrial product (Santaliub-493); and (4) 25% concentrate of zinc arylphosphinate (EFO-Zn). The procedure is described and the results are discussed. It is shown that the temperature of decomposition of these additions, ranging from 170 to 250°C, depends on the nature of the lubricant and the presence of other additions.

V. Z.

### A65-14877 #

#### PROBLEM OF THE METHODS OF ESTIMATING THE ACID-ALKALINE PROPERTIES OF OILS WITH ADDITIONS [K VOPROSU O METODAKH OTSENKI KISLOTNO-OSNOVNYKH SVOISTV MASEL S PRISADKAMI].

V. S. Luneva.

Khimiia i Tekhnologiiia Topliv i Masel, vol. 9, Dec. 1964, p. 56-61, 17 refs. In Russian.

## A65-14886

Discussion of the relative efficiency of titration with indicators, and potentiometric titration in determining the reaction of oils with additions which have often diverse acid-alkaline properties. The effects of a large number of additions, used in the USSR, on the pH of motor oils are examined and the suitability of both titrations for a pH determination is assessed. V. Z.

## A65-14886

### SEALING IN ENGINEERING.

Karel Holan (National Shipbuilding Enterprise, Czechoslovakia). IN: INTERNATIONAL CONFERENCE ON FLUID SEALING, 2ND, CRANFIELD, ENGLAND, APRIL 6-8, 1964, PROCEEDINGS. [A65-14878 05-15]

Edited by B. S. Nau, H. S. Stephens, and D. E. Turnbull. Harlow, British Hydromechanics Research Association, p. E5-73 to E5-88. 5 refs.

Presentation of the theory and design of screw-type clearance seals. Clearance and contact seals in general are discussed. A hydrostatic seal design is described in detail, and calculations of the flow of liquid through the seal and of friction losses are presented. It is stated that such a seal should be suitable for a turbo-compressor, for example. (Author) M.M.

## A65-14894

### EFFECT OF SHAFT ECCENTRICITY ON OIL SEAL.

H. Ishiwata (Nippon Oil Seal Industrial Co., Ltd., Tokyo, Japan) and F. Hirano (Kyushu University, Fukuoka, Japan). IN: INTERNATIONAL CONFERENCE ON FLUID SEALING, 2ND, CRANFIELD, ENGLAND, APRIL 6-8, 1964, PROCEEDINGS. [A65-14878 05-15]

Edited by B. S. Nau, H. S. Stephens, and D. E. Turnbull. Harlow, British Hydromechanics Research Association, p. H2-17 to H2-32; Discussion, p. H-73, H-76 to H-81.

Experimental investigation of the occurrence of leakage through the oil seal due to the wobbling caused by shaft eccentricity. It is stated that the results obtained clearly indicate the allowable limit of the oil seal lip with the eccentric motion. In addition, it is noted that the allowable limit is independent of shaft speed in the practical range and that it cannot be estimated quantitatively, unless the visco-elastic property of the seal material is taken into consideration. In addition, it is found that the shape, material, and interference of the seal lip have great influence on the depression of the sealing ability caused by the dynamic behavior of the seal lip. (Author) M.M.

## A65-15126

### PRINCIPLES OF STRESS CORROSION CRACKING AS RELATED TO STEELS.

J. F. Bates and A. W. Loginow (United States Steel Corp., Applied Research Laboratory, Monroeville, Pa.). (National Association of Corrosion Engineers, Northeast Regional Conference, Niagara Falls, N.Y., Oct. 22, 1963.) Corrosion, vol. 20, June 1964, p. 189t-197t. 31 refs.

General discussion of stress-corrosion cracking phenomena. Possible mechanisms causing the cracking or embrittlement are considered to be electrochemical dissolution, alloying, and hydrogen embrittlement of steels in solutions and liquid metals. Aspects of the electrochemical mechanism and the alternate mechanical-electrochemical mechanism are examined. Stress corrosion cracking in ferrous alloys and proposed stress corrosion mechanisms as they relate to these alloys are considered. The effects of steel composition, mechanical properties, heat treatment stress level, cold work, welding, and corrosive environment on the susceptibility to stress corrosion cracking are discussed. It is considered that stress relieving, cathodic protection, alloy selection, and modification of environment are useful preventive measures. F.R.L.

## A65-15517 #

### BRUSHES OF AIRCRAFT ELECTRIC GENERATORS [SZCZOTKI DO SAMOLOTOWICH MASZYN ELEKTRYCZNYCH].

Kwiryń Zuchowicz. Instytut Lotnictwa, Prace, no. 23, 1964, p. 55-62. 10 refs. In Polish.

Discussion of the performance of brushes of airborne electric generators. The causes for the rapid wear of brushes in high-altitude conditions are examined, and the protection of the commutator surface is discussed. Various types of friction-diminishing agents are noted. V. P.

## A65-15679 #

### FUNDAMENTALS OF HYDRODYNAMIC LUBRICATION AND THEIR CONSEQUENCES IN DESIGN ENGINEERING. II.

F. H. Theyse (Delft, Technological University, Machine Elements Laboratory, Delft, Netherlands).

Wear, vol. 7, Nov.-Dec. 1964, p. 477-497.

Second part of a review of hydrodynamic lubrication, emphasizing that lubricant films, extremely thin relative to the principal dimensions of the shaft and bearing, can be produced by this technique. The scale effect, an optimum cylindrical bearing, the instability of radial, hydrodynamic, fully lubricated slider bearings, and the power loss and heat balance in the standard radial hydrodynamic sleeve bearing are discussed at length. Vogelpohl's volume law is considered essential for a rapid determination of whether a full film lubrication can be achieved in a particular radial bearing. V. Z.

## A65-15680 #

### THE BURNISHING OF MOLYBDENUM DISULPHIDE ON TO METAL SURFACES.

R. R. M. Johnston and A. J. W. Moore (Commonwealth Scientific and Industrial Research Organization, Div. of Tribophysics; Melbourne, University, Melbourne, Australia).

Wear, vol. 7, Nov.-Dec. 1964, p. 498-512. 13 refs.

Research supported by H. C. Sleight, Ltd.

Discussion of the process of burnishing MoS<sub>2</sub> onto copper surfaces under controlled conditions of load, surface finish of the substrate, and relative humidity of the surrounding atmosphere. The film density measured by X-ray fluorescence is found to increase first approximately exponentially and then linearly with the number of strokes. The exponential portion depends on the surface finish and represents the filling of surface asperities with MoS<sub>2</sub>. The slope of the linear portion depends on the load and relative humidity and represents the deposition of MoS<sub>2</sub> on itself. Prediction of the size of surface irregularities is seen possible from film growth rates. X-ray diffraction shows that the films obtained in dry air have fewer particles oriented parallel to the basic plane, which agrees with the lower bulk density for such films as predicted from the burnishing results. Observations are made concerning the occurrence of different types of bonding between MoS<sub>2</sub> particles in dry and humid conditions. (Author) V. Z.

## A65-15681 #

### BOUNDARY LUBRICATION OF CHROME STEEL.

Robert S. Owens and Richard W. Roberts (General Electric Co., Research Laboratory, Schenectady, N.Y.).

Wear, vol. 7, Nov.-Dec. 1964, p. 513-515.

Discussion of the use of iodine-anisole and iodine-anisole-turbine oil as boundary lubricants for chrome steel, instead of turbine oil alone. A reduction of the coefficient of friction and a marked decrease in wear are found to result from the substitution. The surface profiles of wear obtained with the lubricants are diagramed. V. Z.

## A65-15683 #

### THE BEHAVIOUR OF FILMS ON SLIDING SURFACES.

R. T. Spurr (Ferodo, Ltd., Chapel-en-le-Frith, Derby, England).

(Institute of Physics and Physical Society, Conference on Some Aspects of Surface Behavior, Bristol, England, Sept. 17, 1963.) Wear, vol. 7, Nov.-Dec. 1964, p. 551-557. 11 refs.

Discussion of effects of surface films on seizure, pressure welding, sintering, friction, and boundary lubrication of metals. The experiments, conducted for the most part on small-scale equipment, are amplified by tests with wheeled 20-ton trolleys in the later stage of the study. The materials tested as lubricants tend by their effects and behavior to fall into three groups: (1) water, carbon tetrachloride and n-heptane, slightly reducing  $\mu$ ; (2) fatty acids, causing a drastic  $\mu$  drop, down to about 0.1; and (3) polar materials like nitropropane, producing intermediate reduction of friction. The work is presented as a small part of a larger study of rail-wheel adhesion. V. Z.

**A65-15941****SOLIDS AND SOLID LUBRICATION.**

M. J. Devine, E. R. Lamson, J. P. Cerini, and R. J. McCartney (U. S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.).

*Lubrication Engineering*, vol. 21, Jan. 1965, p. 16-26. 44 refs. Navy-sponsored research.

Presentation of a review covering solid-lubricant classification, methods of preparation, examples of engineering applications, and techniques for studying the different properties of solid lubricants, with extensive literature references. The results of new laboratory research are described, showing the degree of influence exerted by bearing design, lubricant-bearing interaction, and metal surface pretreatment on the wear properties of solid-lubricated surfaces.

(Author) F.R.L.

**A65-16168**

**PROTECTION AGAINST CORROSION OF ROTATING ASSEMBLIES OF REACTOR UNITS OF TURBOMECA MARBORE II ON NORD 2500 [PROTECTION CONTRE LA CORROSION DES ENSEMBLES TOURNANTS DES GROUPES REACTEURS D'APPOINT TURBOMECA MARBORE II SUR NORD 2500].**

M. Vialatte (Services Techniques de l'Armée, Paris, France), J. Szydowski (Turboméca S.A., Bordes, Basses-Pyrénées, France), and A. Mihail (Bureau Veritas; Génie Maritime, Paris, France). *Technique et Science Aéronautiques et Spatiales*, May-June 1964, p. 211-220. 8 refs. In French.

Experimental investigation of the corrosion-proofing of the rotating assemblies of reactor units. The subjects considered are: (1) requirements of corrosion protection, (2) tests of reproducibility of the phenomenon, (3) protective coating tests on specimens, (4) protective coating tests on cylinders, (5) coatings adopted, (6) preparation of parts to corrosion protection, (7) bench testing, (8) flight testing of parts protected by chromium-plating, (9) flight testing of parts protected by nickel- and chromium-plating, (10) testing of parts protected by aluminum-plating, and (11) other applications.

M.M.

**A65-16238 #**

**STUDY OF STRUCTURAL ALLOYS BELONGING TO THE Al-Zn-Mg SYSTEM.**

Yoshio Baba and Yoshihiko Sugiyama (Sumitomo Light Metal Industries, Ltd., Technical Dept., Tokyo, Japan).

*Light Metals* (Tokyo), Nov. 1964, p. 371-393. 8 refs. In Japanese, with summary in English.

Experimental investigation of the welding crack sensitivity, strength, and resistance to stress corrosion cracking of an Al-Zn-Mg system containing 4~8% Zn, 0.6~3.0% Mg and a small amount of Cr or Zr when welded with three types of filler metals (Al-5% Zn-2% Mg-2% Si-0.1% Ti, 5056 and same alloy). The findings are: (1) among the three, the products welded by a filler metal of 5056 alloy show the least tendency to zone cracking from welding heat. Regardless of filler metal, the welding cracks increase in inverse proportion to the decrease of Mg content in the parent metals, but are not influenced by the Zn content in the above-mentioned range. Welds of the Al-Zn-Mg alloy in the range of higher content of Zn and Mg are apt to crack under bending stress; (2) all of the welded products can make almost maximum recovery of strength within 90 days of natural aging after welding; (3) the resistance to stress corrosion cracking of the welds in the alloy containing both 0.17%Cr and 0.10%Zr is rather superior to that of 0.2%Cr alone. It seems that the resistance to stress corrosion cracking of the welds is lower than that of the parent metals.

M.M.

**A65-16273**

**NEW FORMS OF BEARING - THE GAS AND THE SPIRAL GROOVE BEARING.**

E. A. Muijderland (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).

*Philips Technical Review*, vol. 25, Oct. 2, 1964, p. 253-274. 14 refs.

Discussion of types of bearing in which friction and wear are reduced to very small proportions by the agency of a viscous fluid (lubricant) that serves to maintain a small and more or less constant clearance between the bearing surfaces. A "contactless" bearing of this kind does not necessarily have to be lubricated with

a liquid, such as oil; a gas is also effective. Particular attention is given to gas-lubricated bearings which have been a practical possibility for the past 15 years or so. Examples of gas bearing applications may be found in turbojet engines, gyroscopic compasses, nuclear reactors, and dentists' drills. On the basis of the self-acting contactless bearing, a new type - the spiral groove bearing - has been developed. Its main advantage is its very low coefficient of friction. A flat thrust bearing of the spiral groove type has a friction coefficient only about one-seventh that of a Michell bearing under comparable optimum conditions. Besides a low coefficient of friction, a variant in which the grooves are cut into a spherical cap has a load-carrying capacity about 25 times greater than that of a corresponding Michell bearing. Small spiral groove bearing having diameters of a few millimeters, and lubricated with grease, promises to be useful in small domestic and other appliances.

(Author) D.H.

**A65-16350 #**

**FLOW OF A NONLINEARLY VISCOPLASTIC MEDIUM BETWEEN TWO PLATES [TECHENIE NELINEINO-VIAZKO-PLASTICHESKOI SREDY MEZH DU DVUMIA PLASTINKAMI].**

A. A. Tamonov.

IN: INVESTIGATIONS OF ELASTICITY AND PLASTICITY. II [ISSLEDOVANIE PO UPUGOSTI I PLASTICHNOSTI. SBORNIK 2]. Edited by L. M. Kachanov.

Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1963, p. 203-211. In Russian.

Discussion of the problem of a flow between two unparallel plates, generalized to cover the case of a medium whose plastic viscosity is exponentially dependent on the deformation rate. The discussion is motivated by the observed fact that curved flows of viscoplastic lubricants may not obey the Shvedov-Bingham equation when the relationship between strains and deformation rates is relatively weak. Expressions for pressure in lubricant layers are derived, and an analysis of lubricant behavior is carried out showing that a nonlinearly viscoplastic lubricant is superior to common viscous lubricants in lessening and leveling the pressure in the lubricating layer.

V.Z.

**A65-16468**

**BALL AND ROLLER BEARINGS.**

*Lubrication*, vol. 1, Dec. 1964, p. 149-164.

Extensive discussion and description of types of anti-friction bearings and their lubrication. Following a brief description of principles, several types of ball, roller, and needle bearings are described and illustrated. The functions of lubricants, either oil or grease, are listed, and methods of maintaining lubricant levels are discussed, as well as factors affecting choice of oil or grease for the lubricant. Oil-jet lubrication is used for aircraft gas turbines. Grease lubrication involves selection of types of grease, all of which have various advantages and limitations. Ball, roller, and needle bearing maintenance is considered. Bearing materials, and shields and seals, are discussed, and the methods of manufacturing anti-friction bearings are briefly examined.

F.R.L.

**A65-16663**

**MOLECULAR PHYSICS OF BOUNDARY FRICTION [MOLEKULARNAIA FIZIKA GRANICHNOGO TRENIYA].**

A. S. Akhmatov.

Moscow, Gosudarstvennoe Izdatel'stvo Fiziko-Matematicheskoi Literatury, 1963. 472 p.

The monograph, first of its kind in Russian, seeks to fill the gap in the literature on the subject, by summarizing modern knowledge of the phenomena occurring on the surface of solids (metals) known as boundary friction. Both the theoretical and technological aspects of the subject are treated in the eleven chapters devoted to the discussion of molecular forces, the structure and behavior of metallic surfaces, the structure and deformation of hydrocarbon chain molecules, crystalline hydrocarbons, the classical theory of transition layer, liquid and solid boundary layers, the physical properties of lubricant boundary layers, boundary friction as such, applications of the molecular physics of boundary layers to technological problems, and technique and equipment used in the study of boundary friction. An extensive list of literature, tables of physical properties of normal paraffins, saturated fatty acids, primary normal alcohols, and a table of molecule dipole moments of some

hydrocarbons are supplied. The monograph is intended for scientists engineers, postgraduates, and advanced students dealing with the physics of metals or working in related fields. V. Z.

#### A65-16816

##### LUBRICATION.

Dudley D. Fuller (Columbia University, Dept. of Mechanical Engineering, New York, N. Y.; Franklin Institute, Philadelphia, Pa.).

International Science and Technology, Jan. 1965, p. 18-27.

Review of the principles underlying the application of exotic lubricants that are neither slippery nor viscous but are able to withstand the extremes of temperature, high vacuum, and ionizing radiation encountered in the space environment. Most involve fluid film lubrication in which the sliding surfaces are completely separated by the lubricant. There is a trend toward the use of fluids or gases already present in a system - e. g., the same mercury that drives a turbine designed to produce electricity from solar heat lubricates the bearings, and a nuclear reactor pump that circulates a slurry of acid and hard radioactive particles uses a slurry of nitric acid and 5% sand for lubrication. Such methods eliminate seals, the need for servicing, and the risk of contamination. However, problems arise in connection with the generally low load-bearing capacity, operation at high speed, unstable motion of the shaft within its bearing clearance, and turbulence in the fluid film. Several design solutions for appropriate bearings are presented.

W. M. R.

#### A65-16908

##### AIRCRAFT MATERIALS [AVIATIONNOE MATERIALOVOEDENIE].

A. E. Leikin, E. S. Porotskii, and B. I. Rodin.

Moscow, Izdatel'stvo Mashinostroeni, 1964. 460 p. In Russian.

This textbook is designed as an aid to technicum students in the selection of various aircraft materials for a specific application. It describes the characteristics of the principal metallic and non-metallic materials used in aircraft structures and reviews the methods used to investigate the properties of alloys, radiographic and other flaw-detection methods, methods of thermal and thermochemical treatment, and methods of protection against corrosion.

V. P.

#### A65-16986

##### IMPROVING ULTRASONIC MACHINING RATES - SOME FEASIBILITY STUDIES.

W. Pentland and J. A. Ektermanis (Therm, Inc., Ithaca, N. Y.).

(American Society of Mechanical Engineers, Production Engineering Div., and American Society of Tool and Manufacturing Engineers, Conference and Exposition, Detroit, Mich., Apr. 20-24, 1964, Paper 64 - Prod-4.)

ASME, Transactions, Series B - Journal of Engineering for Industry, vol. 87, Feb. 1965, p. 39-46; Discussion, Paul Rosenthal (Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.), p. 46. 12 refs.

Contract No. AF 33(600)-42921.

Investigation of the effects that several different work material and process variables have on removal rates for ultrasonic machining. The phenomena considered include hardness and applied stress of work material, slurry temperature, grit size, slurry application, tool vibration amplitudes, low-temperature and stress-corrosion embrittlement of work material, and liquid-metal corrosion effects on work material. It is postulated that three basic mechanisms are involved in ultrasonic machining: (a) microchip removal due to plastic deformation by shear; (b) microparticle removal by fracture of hard or work-hardened material; and (c) displacement of material at the treatment surface without removal, by plastic deformation.

#### A65-17005

##### A NEW SMALL-SCALE METHOD FOR MEASURING FUEL THERMAL STABILITY.

F. Burggraf and M. Shaysen (General Electric Co., Flight Propulsion Div., West Lynn, Mass.).

Society of Automotive Engineers, International Automotive Engineering Congress, Detroit, Mich., Jan. 11-15, 1965, Paper 987A, 10 p.

Members, \$0.75; nonmembers, \$1.00.

Research supported by the USAF, Coordinating Research Council, NASA, and FAA.

Discussion of a miniature single-tube heat exchanger, termed Minex, for making precise measurements of the fuel-side heat-transfer coefficient. The conditions of turbulent flow, temperature level, and heat flux are maintained to simulate flight at high Mach numbers. The decay of the fuel-side coefficient, due to the deposition of varnish film at high temperatures, is measured over extended time intervals. The rate of decay of the coefficient as a function of temperature is a quantitative measurement of the thermal stability of the fuel. (Author) V. P.

#### A65-17229

##### THE MECHANISM OF OXIDATION, HYDROGENATION, AND ELECTROCHEMICAL OXIDATION ON SOLID CATALYSTS. IX - FUNCTIONING OF MEMBRANE ELECTRODES (MEMBRANE-TYPE CATALYSTS) IN THE ELECTROCHEMICAL OXIDATION OF GASES AND IN OTHER HETEROGENEOUS PROCESSES.

O. K. Davtian (Odesskii Gosudarstvennyi Universitet, Odessa, Ukrainian SSR).

(Zhurnal Fizicheskoi Khimii, vol. 38, Apr. 1964, p. 825.)

Russian Journal of Physical Chemistry, vol. 38, Apr. 1964, p. 449-453. 7 refs. Translation.

Examination of the principles of operation of membrane gas electrodes (membrane-type catalysts). Two methods of producing an active three-phase boundary are considered: (1) by applying a water-repellent treatment to the electrode, and (2) by creating a pressure difference between reactant gases and electrolyte. It is noted that the artificial water-repellent treatment must be carried out so that the electrode acquires a definite wettability gradient; the greatest concentration of hydrophobic substance in the electrode must be on the gas side. When an electrode operates on the basis of a pressure difference between gas and liquid, a single-layer electrode and an electrode having an inactive sealing layer must be "nonhomoporous." The mechanism of the successive stages in current-producing processes (chemisorption of gas, migration of chemisorbed species to active portions of three-phase boundaries, and ionization of chemisorbed species) is discussed. A precise definition of the concept of an active three-phase boundary is given.

J. R.

#### A65-17481

##### FRICITION OF SOLID FILM LUBRICANTS BEING DEVELOPED FOR USE IN SPACE ENVIRONMENTS.

Vern Hopkins and Donald Gaddis (Midwest Research Institute, Engineering Materials Section, Kansas City, Mo.).

(American Society of Lubrication Engineers, Annual Meeting, 19th, Chicago, Ill., May 26-28, 1964.)

Lubrication Engineering, vol. 21, Feb. 1964, p. 52-58; Discussion, M. J. Devine (U.S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.), p. 58.

Contract No. NAS 8-1540.

Description of the evaluation of inorganic solid-film lubricants being developed for space environments. Friction coefficients are given for many potential lubricants subjected to a light load and temperature from 80 to 400°F in both a normal air atmosphere and in a vacuum at  $10^{-6}$  torr. The principal criterion for judging the performance of a potential lubricant film was the friction coefficient, which must be less than that obtained for a 0.001-in.-thick film of gold. It is stated that the following lubricant films exhibited lower overall friction coefficients than a 0.001-in.-thick gold film: (1)  $\text{MoS}_2$  + graphite + bismuth/sodium silicate; (2)  $\text{MoS}_2$  + graphite + gold/sodium silicate; (3)  $\text{MoS}_2$  + graphite + molybdenum/sodium silicate; (4)  $\text{MoS}_2$  + graphite/sodium silicate; and (5)  $\text{MoS}_2$  + graphite/sodium phosphate.

(Author) M. M.

#### A65-17527

##### CAVITATION IN THIN FILMS OF LUBRICANT.

J. B. Hunt (Southampton, University, Dept. of Mechanical Engineering, Southampton, England).

The Engineer, vol. 219, Jan. 29, 1965, p. 221, 222. 5 refs.

Proposal that the pitting that causes the wear of gear teeth, the wear in bearing materials, or any wear of the "pitting" nature found where thin films of lubricant are employed, could be due to cavitation. It is shown that cavitation and the resulting damage can occur when lubricant films of similar thickness to those existing between gear teeth and bearing faces are subjected to amplitudes and frequencies of vibration similar to those caused by the expansion of the hydraulic wedge as two gear teeth faces separate, or by the

natural vibration of the gear teeth, or by the radial oscillation of shafts in bearings. (Author) D. H.

#### A65-17805

##### ELECTROCHEMICAL SEPARATION OF TUNGSTEN AND TITANIUM CARBIDE.

L. A. Mashkovich, A. F. Kuteinikov, and T. P. Maslova. (*Zavodskaya Laboratoriya*, vol. 30, July 1964, p. 788-791.)  
(*Industrial Laboratory*, vol. 30, Feb. 1965, p. 987-989. Translation.)

Investigation of polarization processes occurring during electrochemical phase analysis of cermet alloys containing tungsten metal and titanium carbide. It was found that the best medium for separation is 5% NaOH. The effect of anions on the potentials of tungsten metal and titanium carbide was also investigated.

(Author) A. B. K.

#### A65-17897 #

##### LUBRICANTS FOR RAPID FIRE AUTOMATIC WEAPONS.

J. Messina, L. F. Peale, H. Gisser (U. S. Army, Frankford Arsenal, Philadelphia, Pa.), and K. R. Fisch (USAF, Materials Central, Wright-Patterson AFB, Ohio).

(*NLGI Annual Meeting*, 31st, Pittsburgh, Pa., Oct. 1963.)

*NLGI Spokesman*, June 1964. 6 p.

Description of a semifluid grease and an oil blend which permit satisfactory operation of the multibarrel, high-speed, rapid-firing M61 gun over the temperature range  $-65^{\circ}$  to  $+260^{\circ}\text{F}$ . The composition of the semifluid grease is: 89.0% bis(2-ethylhexyl) sebacate, 1.5% barium dinonyl naphthalene sulfonate, 0.5% 2,6, di-tert-butyl-p-cresol, 1.0% diisopropyl phosphite, and 8.0% lithium stearate. The oil blend contains 94.5% bis(2-ethylhexyl) sebacate, 1.5% barium dinonyl naphthalene sulfonate, 0.5% 2,6, di-tert-butyl-p-cresol, 0.5% diisopropyl phosphite, and 3.0% tricresyl phosphate. In laboratory evaluations both lubricants exhibit effective anti-wear and extreme-pressure properties, as well as oxidation and storage stability and rust-protection ability. Extensive firing tests over the temperature range from  $-65^{\circ}$  to  $+260^{\circ}\text{F}$  showed that both lubricants permitted adequate functioning. The semifluid lubricant, however, permitted a longer relubrication cycle and, as a result, was selected over the oil blend for lubrication of the M61 gun.

(Author) A. B. K.

#### A65-18051

##### THE LUBRICATION MECHANISM OF TRICRESYL PHOSPHATE ON STEEL.

Douglas Godfrey (California Research Corp., Richmond, Calif.).

(*American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC - 1.*)

*ASLE Transactions*, vol. 8, Jan. 1965, p. 1-10; Discussion, Michael J. Furey (Esso Research and Engineering Co., Linden, N.J.) and Clarence Albertson (Borg-Warner Corp., Roy C. Ingersoll Research Center, Des Plaines, Ill.), p. 10, 11; Author's Closure, p. 11. 45 refs.

Discussion of the results of a literature survey showing that the lubricating mechanism of tricresyl phosphate (TCP) is not clear. The theory of polishing by formation of an iron-iron phosphide eutectic is not supported. Wear reduction by the formation of iron phosphate is seen to be a more likely explanation. Experimental work is discussed which shows that, when steel sliding on steel is lubricated with TCP, a film consisting of a mixture of  $\text{FePO}_4$  and  $\text{FePO}_4 \cdot 2\text{H}_2\text{O}$  is formed. Other friction and wear experiments, as well as film analyses, are shown to support the phosphate mechanism.

(Author) M. L.

#### A65-18052

##### EFFECTS OF $\text{P}^{32}$ IMPURITIES ON THE BEHAVIOR OF TRICRESYL PHOSPHATE-32 AS AN ANTIWEAR ADDITIVE.

E. E. Klaus and H. E. Bieber (Pennsylvania State University, Dept. of Chemical Engineering, Petroleum Refining Laboratory Div., University Park, Pa.).

(*American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC - 2.*)

*ASLE Transactions*, vol. 8, Jan. 1965, p. 12-19; Discussion, Louis R. Stark (Monsanto Chemical Co., St. Louis, Mo.) and Michael J. Furey (Esso Research and Engineering Co., Linden, N.J.), p. 19, 20; Authors' Closure, p. 20. 14 refs.

Contract No. AF 33(657)-10374.

Investigation using commercial tricresyl phosphate-32 (TCP-32) to illustrate the involvement of  $\text{P}^{32}$  in physical adsorption and chemical reaction at the bearing surface. Chromatographic analyses of three commercial batches of TCP-32 indicate the presence of appreciable quantities of polar  $\text{P}^{32}$  impurities. Thin-layer and iron-powder chromatography are studied as analytical tools for the quantitative measurement and separation of TCP-32 from its  $\text{P}^{32}$  impurities. The effect of the polar  $\text{P}^{32}$  impurities on physical adsorption on the bearing surface is illustrated as a function of polar  $\text{P}^{32}$  impurity concentration. The effect of a variety of surface-active additives on  $\text{P}^{32}$  adsorption at the bearing surface is also studied. The wear properties of TCP, acid phosphates, and acid phosphites in several base stocks are investigated to illustrate the effects of polar impurities on the antiwear properties of TCP. The presence of  $\text{P}^{32}$  chemically combined with the bearing metal is suggested by the wear studies with TCP-32. A definite relationship is shown to exist between effective antiwear behavior and a high level of  $\text{P}^{32}$  chemically combined with the worn bearing surface.

(Author) M. L.

#### A65-18053

##### CHEMISTRY OF BOUNDARY LUBRICATION OF STEEL BY HYDROCARBONS.

R. S. Fein and K. L. Kreuz (Texaco, Inc., Research Center, Beacon, N.Y.).

(*American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC - 4.*)

*ASLE Transactions*, vol. 8, Jan. 1965, p. 29-37; Discussion, R. S. Owens, L. E. St. Pierre, and R. W. Roberts (General Electric Co., Research Laboratory, Schenectady, N.Y.), p. 37; Authors' Closure, p. 37, 38. 21 refs.

Investigation of boundary lubrication by hydrocarbons using a four-ball machine with 52100 steel specimens at 0.35 cm per second sliding velocity. The chemical type of the hydrocarbon and the amount of oxygen dissolved in it are found to be important. Low molecular weight liquid-aromatic hydrocarbons exposed to ambient air are found as effective as straight mineral oils in controlling wear, while saturated hydrocarbons are found to be generally poorer. Benzene and cyclohexane are used as model lubricants in the study of oxygen concentration in vapor and liquid phase. Both high and low oxygen-to-hydrocarbon ratios favor high wear and inorganic wear products. Certain intermediate ratios are seen to result in low wear and the formation of an oxygenated organic "friction polymer" which prevents metallic contact. The results are discussed in the light of available information concerning catalytic reactions at clean metal surfaces.

(Author) M. L.

#### A65-18054

##### BOUNDARY LUBRICATION BEHAVIOR OF ORGANIC FILMS AT LOW TEMPERATURES.

J. A. Russell, R. A. Burton, P. M. Ku (Southwest Research Institute, San Antonio, Tex.), and W. E. Campbell (Rensselaer Polytechnic Institute, Troy, N.Y.).

(*American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC - 6.*)

*ASLE Transactions*, vol. 8, Jan. 1965, p. 48-57; Discussion, H. Gisser (U.S. Army, Frankford Arsenal, Pitman-Dunn Institute for Research, Philadelphia, Pa.), p. 58; Authors' Closure, p. 58. 12 refs.

Contract No. AF 33(657)-11088.

Discussion of sliding experiments on metals lubricated with thin films of hydrocarbons, fatty acids, and synthetic lubricants in helium and air. The temperature range  $-195$  to  $+200^{\circ}\text{C}$  is investigated. For copper and iron pairs lubricated with pure organic compounds, a marked rise in friction and wear is found to occur at the melting point of the film material. From just below the melting point down to  $-195^{\circ}\text{C}$ , there is an increase in friction but negligible wear, indicating increased shear strength of the solid film. This is substantiated by contact-resistance measurements. The behavior of fatty acids in dry air indicates that oxygen promotes the formation of higher-melting soap and defers the friction rise to the melting point of the soap. Humidity is found to displace the friction rise to an even higher temperature.

(Author) M. L.

**A65-18055****EFFECTS OF LUBRICANTS ON TRANSITION TEMPERATURES.**

R. S. Fein (Texaco, Inc., Research Center, Beacon, N. Y.).  
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC - 7.)  
ASLE Transactions, vol. 8, Jan. 1965, p. 59-66; Discussion, David Tabor (Cambridge University, Cavendish Laboratory, Cambridge, England) and Vern Hopkins (Midwest Research Institute, Kansas City, Mo.), p. 66, 67; Author's Closure, p. 67, 68. 22 refs.

Confirmation and extension of studies of transitions between low and high friction and wear in the four-ball machine, using lubricants consisting of noncyclic hydrocarbons and dilute solutions of stearic acid and cetane and squalane. These materials show transition temperatures which are the same for AISI 4140 and 52100 steels and which increase with increasing ratio of speed to load. Hydrocarbons with cyclic structures are found to show similar performance with 4140 steel and, at high speed-load ratios, with 52100 steel. However, with the 52100 steel at low speed-load ratios, there is a speed-load ratio independent transition temperature. Neat stearic acid with 52100 steel is found to show similar performance to the cyclic hydrocarbons with the speed-load ratio independent transition temperature agreeing with pin-on-disk machine results on other steels in the literature. These results and results obtained from the literature are discussed using a mechanism involving viscous trapping of lubricant between interacting load-supporting asperities. (Author) M. L.

**A65-18057****NEW METHODS OF INVESTIGATION OF LUBRICANT PROPERTIES.**

Iu. S. Zaslavskii, G. I. Shor, I. A. Morozova, F. B. Lebedeva, E. V. Evstigneev, and R. N. Shneerova (All-Union Scientific Research Institute for Oil Refining, Moscow, USSR).  
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC - 9.)  
ASLE Transactions, vol. 8, Jan. 1965, p. 78-84. 6 refs.

Investigation of the mechanism of the true detergent action of motor-oil additives. The sorption of the charged additive particles on the surface of the carbonaceous products of fuel combustion and oil oxidation, as well as on the surface of engine metal parts, is studied. The data confirm the impression that the charged additive particles characterized by low  $E_0$  values should have a greater relative sorption ability as compared to the particles with higher  $E_0$  values. The conclusion is reached that oil solutions of the tested additives possessing true detergent and deflocculating properties are anhydrous electrolytes, as their dissociation degree sharply increases with the decrease in the additive concentration. They obey Ohm's law, and they are electrolyzed, practically all of the additive depositing on the electrodes as decomposition products. A greater mobility of the cation particles as compared with the anion particles has been found. A radiotracer method for the simultaneous evaluation of antiwear and detergent properties of motor oils and a radiotracer method for the evaluation of the chemical activity of EP additives are discussed. M. L.

**A65-18331****FRICITION AND WEAR.**

E. Rabinowicz (Massachusetts Institute of Technology, Cambridge, Mass.).  
Product Engineering, vol. 36, Mar. 15, 1965, p. 95-99.

Extension of the adhesion-plastic deformation theory by the addition of quantitative surface energy terms. The existence of surface attraction forces at the junctions is acknowledged but not taken into account in the conventional theory. The predictions of the modified theory are found to be accurate for a number of metals and nonmetals. Numerical examples are given and a friction chart is presented from which the general rule emerges that, for low friction, lubricated surfaces should be metals, while unlubricated surfaces should be nonmetals. W. M. R.

**A65-18627****ADHESION BETWEEN FRETTING STEEL SURFACES.**

B. Bethune and R. B. Waterhouse (Nottingham University, Dept. of Metallurgy, Nottingham, England).  
Wear, vol. 8, Jan.-Feb. 1965, p. 22-29.

Experimental investigation of the effects of the hardness, varied both by composition and heat treatment, of the steel bridges on their adhesion to, and their damaging effect, vis a vis fatigue, on a cold-drawn mild steel, in view of the importance of this initial stage of the fretting process in the initiation of fatigue cracks. It is stated that, from the photomicrographs, it would appear that the extensive welds formed in the early stages occur as a result of disruption of surface oxide films. These are then broken by fatigue-producing distortion of the surfaces. It is stated that the severe fatiguing in this operation probably initiates the fatal fatigue crack. The two roughened surfaces then continue to rub together, and the asperities butt against one another forming the smaller but quite strong welds, which are in turn broken by fatigue, initiating further fatigue cracks. It is noted that the 0.56% C steel in both conditions, although it showed no adhesion in the early stages of fretting as measured by the rather crude experimental method, probably did in fact develop small welded areas which were sufficient to initiate fatigue cracks. M. M.

**A65-18628****FRETTING CAUSES FAILURE OF A WC-Co-COATED SLIDE BEARING.**

J. F. Hildebrand and W. H. Watson (General Dynamics Corp., General Dynamics/Fort Worth, Fort Worth, Tex.).  
Wear, vol. 8, Jan.-Feb. 1965, p. 34-42. 7 refs.

Description of a leakage problem encountered in hydraulic actuators because of wear in the rod-gland bearing which consisted of a chromium-plated steel rod and a silver-plated steel gland. To improve the actuator life, the gland was changed to 440C stainless steel and the rod was plasma arc-coated with WC-Co. It is stated that this combination of materials gave a marked improvement in the wear resistance under long-stroke cycling but created a new problem associated with rapid short-stroke cycling. Fretting induced by the rapid short-stroke cycling caused the cobalt-rich phase of the rod coating to cold-weld to the gland. Then fatigue failures in the WC-Co coating allowed metal transfer in the bearing and subsequent scoring of the rod. An economical remedy was found in a woven Teflon-fiber liner bonded to the bearing surface of the gland. (Author) M. M.

**A65-18629****A NOTE ON THE RELATION BETWEEN THE ABRASION RESISTANCE AND THE HARDNESS OF METALS.**

C. Rubenstein (Manchester College of Science and Technology, Dept. of Mechanical Engineering, Manchester, England).  
Wear, vol. 8, Jan.-Feb. 1965, p. 70-72.

Presentation of comments on the results reported in 1958 by Khurshov of an investigation to determine the dependence of the wear resistance of metals on their hardness by rubbing them against an abrasive surface. The metal specimens traversed a spiral path over the abrasive surface so that contact between specimen and unused abrasive was maintained throughout. To eliminate the influence of fluctuations in the abrasive ability of different regions of the abrasive surface, the wear of any specimen was determined simultaneously with that of an arbitrarily chosen standard material tested on a different part of the same abrasive surface under identical conditions. It is stated that Khurshov chose as standard material a lead-tin alloy, the composition of which was not quoted. From the reciprocal of the slope of the resulting  $E_m$  vs  $H_m$  line, the hardness of this alloy may be deduced to have been  $7.2 \text{ kg/mm}^2$ , which is said to be of the right order of magnitude but rather lower than the hardness quoted by Tabor for Pb 30:Sn 70 solder ( $BHN = 12 \text{ kg/mm}^2$ ). An analysis is performed which is said to provide an explanation of the experimental observations quoted by Khurshov and to suggest that a better presentation of data would be given by plotting  $E_m$  against the relative hardness defined by  $H_m/H_8$  which would yield a straight line passing through the origin and having a slope of unity, this relation being independent of the material chosen as standard. It is pointed out that the wear behavior of heat-treated steels does not conform with the equation given by Khurshov for these materials. M. M.

**A65-18784****CADMIUM-TITANIUM PLATING - AN IMPROVED PROCESS FOR PROTECTING HIGH STRENGTH STEELS.**

Dewey M. Erlwein and Robert E. Short (Boeing Co., Airplane Div., Finishes and Sealants Group, Materials Technology Unit, Seattle, Wash. 1).

*Metal Progress*, vol. 87, Feb. 1965, p. 93-96.

Description of a process for protecting high-strength steels from corrosion by codepositing cadmium with up to 0.5% Ti from an aqueous solution. This technique produces a coating which is said to be more corrosion-resistant than conventional bright cadmium plating and to have less tendency to embrittle high-strength steel. Another advantage of this process is the decrease in baking time necessary to drive off the hydrogen. One possible reason suggested for low hydrogen input is the ability of titanium to pick up and retain the gas, so that that much less enters the steel during plating. Another possible explanation is that the titanium is chemically reduced at the surface of the part by nascent hydrogen, which would result in less hydrogen being available to enter the steel.

A. B. K.

**A65-18793****DEGRADATION OF POLYMERIC COMPOSITIONS IN VACUUM TO  $10^{-9}$  MM Hg IN EVAPORATION AND SLIDING FRICTION EXPERIMENTS.**

D. H. Buckley and R. L. Johnson (NASA, Lewis Research Center, Cleveland, Ohio).

(Society of Plastics Engineers, Annual Technical Conference, Atlantic City, N.J., Jan. 27-30, 1964.)

*SPE Transactions*, vol. 4, Oct. 1964. 9 p. 14 refs.

Determination of the volatility of solid polymer compositions at temperatures to 1100°F, including investigation of their friction characteristics and the mechanisms of wear and decomposition in lubrication experiments. Polymer compositions examined included: fluorocarbon telomers, polytetrafluoroethylene (PTFE), polychlorotrifluoroethylene (PCFE), polyimide, and epoxy compositions. The quantity and nature of the decomposition products formed in the process of polymers sliding on various substrates are determined both by the substrate material and the polymer. Scission of the carbon-to-fluorine bond due to heat was noted in glass-filled PTFE and a reduction in decomposition was observed in copper-filled PTFE. Unfilled polyimide was found to be superior to unfilled PTFE as a slider material in vacuum at ambient temperatures. Fillers did not improve friction characteristics but did reduce wear, in some instances, as much as a factor of 100. Evaporation rates were found to be related to the molecular weights of the materials. Friction, wear, and evaporation results are given graphically.

D.H.

**A65-18794****THE DETERMINATION OF THE COEFFICIENT OF FRICTION AT ELEVATED TEMPERATURES USING A PLANE-STRAIN COMPRESSION TEST.**

J. A. Bailey (Georgia Institute of Technology, School of Mechanical Engineering, Atlanta, Ga.) and A. R. E. Singer (Wales, University, University College of Swansea, Dept. of Metallurgy, Swansea, Wales).

*Institute of Metals, Journal*, vol. 92, 1964-1965, p. 378-380. 8 refs.

Determination of correction factors, based on coefficient of friction at elevated temperatures, for stress-strain curves. The plane-strain compression test employed a hydraulic press to produce compression at constant velocity; loads were measured by means of a strain-gage bridge network, preamplifier, and double-beam oscilloscope. Data, accurate to  $\pm 2\%$ , were recorded photographically. The basic yield curve of the material (super-purity aluminum strip specimens) was determined and compared with the pressure/reduction curve obtained for each of four lubricants (cadmium oxide, molybdenum disulphide, graphite, and graphite plus cadmium oxide) by a "single-indentation" technique. The coefficient of friction was then calculated by applying the analysis of Takahashi and Alexander. The effects of temperature and percentage deformation on coefficient of friction for the four lubricants are plotted and discussed. The results on all the lubricants are in rough agreement with the work of Orcutt et al., although direct comparisons could not be made because of the different methods used. It is found that friction initially increases with deformation and then decreases; the decrease possibly results from lubrication by metal debris but the mechanism is not well understood.

D.H.

**A65-19259****CORROSION OF METALS BY LIQUID FLUORINE.**

Alan H. Singleton, James F. Tompkins, Jr., Sidney Kleinberg (Air Products and Chemicals, Inc., Research and Development Dept., Allentown, Pa.), and C. J. Sterner (American Cryogenics, Inc.).

*I & EC - Industrial and Engineering Chemistry*, vol. 57, Mar. 1965, p. 47-53. 18 refs.

Contract No. AF 33(616)-6515.

Investigation of the corrosive action of fluorine on metals in a dry system free from contaminants. It is found that under these conditions, corrosive action is negligible. Stress corrosion and cracking are not likely to occur with metals exposed to liquid fluorine. Passivation of small metal systems with low pressure or dilute fluorine gas is not a requisite for safe operation; however, this technique does increase the probability of safe operation and is recommended as a final treatment prior to liquid exposure. It has been shown that hydrocarbons invariably form either elemental carbon or combustible liquids when exposed to gaseous fluorine; hence, extreme care must be exercised in eliminating such contaminants prior to gas exposure. It has been shown that exposure of metals to low pressure fluorine gas results in the formation of a very thin film of metal fluoride, on the order of  $10^{-4}$  Å thick. Essentially no deterioration of tensile properties of metals takes place from exposure to liquid fluorine for a one-year period.

D.H.

**A65-19706****ROTORACE GYROS.**

F. Errington and J. J. Jones (Sperry Gyroscope Co., Ltd., Bracknell, Berks., England).

*Institution of Mechanical Engineers, Symposium on Gyros, London, England, Feb. 25, 26, 1965, Paper 13.* 16 p. 9 refs.

Discussion of "Rotorace" gyros, whose average gimbal friction is reduced by the use of special ball bearings, in which a third, intermediate race is rotated forwards and backwards over several revolutions, while the intermediate race in the companion bearing is rotated in the opposite direction. The main large-scale application is for aircraft directional gyros and attitude reference systems. Wander rates of  $0.5^{\circ}$  -  $0.1^{\circ}$ /hr are being achieved. A single-degree-of-freedom miniature Rotorace gyro of inertial quality has also been developed, intended to be used in the first large-scale application of inertial navigation in commercial airlines. The rotation of the bearings makes them less sensitive to the effects of brinelling and dirt, thus improving the reliability of the gyros and reducing manufacturing difficulties and cost.

(Author) F.R.L.

**A65-19790****CORROSION BEHAVIOR UNDER TENSION OF ALUMINUM ALLOY SECTIONS AND FORGED PARTS [TENUUE A LA CORROSION SOUS TENSION DES PROFILS ET DES PIECES DE FORGE EN ALLIAGE D'ALUMINIUM].**

R. Le Grand (Aluminium Français, Paris, France).

(Association Française des Ingénieurs et Techniciens de l'Aéronautique et de l'Espace, Commission des Matériaux, Paris, France, Mar. 9, 1964, Lecture.)

*Technique et Science Aéronautiques et Spatiales*, Sept.-Oct. 1964, p. 399-407. 8 refs. In French.

Examination of corrosion under tension, which has been observed to be a cause of fracture of aluminum alloy parts from the theoretical, experimental, and practical points of view. Observed types of corrosion are classified as either (1) intergranular, which manifests itself suddenly with a reduction of dimensions of the part in healthy metal; or (2) corrosion under tension, which manifests itself by fracture of the part, the structural condition of the material not always being characterized by a very distinct corrosion along the joints of the grains. Although the two types of corrosion are identified and described, it is pointed out that they are interdependent. According to results obtained on different high-resistance alloys, which were cross-checked, and conform to general corrosion theory, it is considered that chemical composition is of importance, and that the conditions of heat treatment have a predominant effect in corrosion under tension. In the case of certain alloys, the influence of the orientation of the fibers in relation to stress plays an essential part.

F. R. L.



**A65-20015 =**

EFFECTIVENESS OF POLYSILOXANES AS ADDITIVES TO PETROLEUM LUBRICATING OIL UNDER VARIOUS FRICTION REGIMES [EFFEKTIVNOST' POLISILOKSANOV KAK PRISADOK K NEFTIANYM MASLAM PRI RAZLICHNYKH REZHIMAKH TRENIYA].

M. I. Nosov and G. V. Vinogradov (Akademiia Nauk SSSR, Moscow, USSR).

*Khimiia i Tekhnologiia Topliv i Masel*, vol. 10, Mar. 1965, p. 52-54. 5 refs. In Russian.

Study of the effect of sliding velocity and temperature on the lubricating properties of solutions of polyethylsiloxane in petroleum and its naphthene-paraffin and aromatic fractions. It is found that elevated temperatures increase the activity of the polysiloxane admixture. On increasing the sliding velocity, the lubricating properties of solutions of polysiloxanes in hydrocarbon media deteriorate, while at lower velocities these properties improve. The synergistic effect, which is most strongly evidenced in 3 to 6% solutions, is believed to be due to decomposition of the polysiloxane during friction leading to the formation of a hard layer of silicon on which is superimposed a much softer layer of oxide (or some other material of favorable composition) that acts effectively as a grease. W. M. R.

**A65-20033**

FACTORS AFFECTING THE PERFORMANCE OF RESIN BONDED SOLID FILM LUBRICANTS.

S. F. Calhoun, F. S. Meade, G. P. Murphy, and R. L. Young (U. S. Army, Rock Island Arsenal, Rock Island, Ill.).

*Lubrication Engineering*, vol. 21, Mar. 1965, p. 97-103. 17 refs.

Summary of the results of work, done by the Petroleum Products Unit of the U. S. Army Rock Island Arsenal Laboratory, Rock Island, Ill., over a period of twelve years, to improve the lubricating ability and corrosion protection afforded by resin-bonded solid-film lubricants. The study was restricted to steel surfaces at ambient temperatures and pressures. Certain metallic oxides and salts were found to act synergistically with the molybdenum disulfide to improve its performance. Graphite improved the wear and EP properties of the lubricant, but promoted galvanic corrosion. An epoxy-phenolic resin system in a 3 : 7 ratio with the solids gave the best overall results. A grit-blasted zinc-phosphated surface gave the best wear life, but a cadmium-plated zinc-phosphated surface gave the best corrosion protection. Studies of cure time and temperature revealed that optimum conditions differed for wear life and corrosion protection. A compromise was arrived at which is said to give both reasonably good wear life and corrosion protection. Contamination of solid-film lubricants by conventional lubricants is indicated as being detrimental to both wear life and corrosion protection. Solvent removal of the contaminating lubricant alleviates this problem. Rust coverage of up to 50% had no appreciable effect upon the wear life of the solid-lubricant-coated surface. (Author) F. R. L.

**A65-20034**

IMPROVED BOUNDARY LAYER LUBRICATION BEHAVIOR.

R. B. Bossler, Jr. (Kaman Aircraft Corp., Bloomfield, Conn.)

*Lubrication Engineering*, vol. 21, Mar. 1965, p. 104-111. 5 refs. Contract No. DA-44-177-TC-716.

Discussion of an empirical investigation of the concept that a surface composed of noninterconnected lubricant reservoirs can have less boundary-layer friction than a smoother surface with an apparent lay. Starting-friction tests were conducted with test pieces simulating the components of a specific sliding bearing application. Various combinations of surfaces produced by grinding and by glass bead peening were tested for the loads, lubricant, and material involved. A combination of noninterconnected reservoir surface finishes was selected which had higher rms and lower starting friction than the ground surface finishes tested. The actual bearing application with the production-ground finishes had measured starting torque values ranging from 54 ft-lb to 84 ft-lb; the most common value was 66 ft-lb. With the rougher noninterconnected reservoir surface finishes, the measured starting torque ranged from 30 ft-lb to 54 ft-lb, the most-common value was 42 ft-lb. Some speculations on the associated lubrication mechanism are offered. (Author) F. R. L.

**A65-20040 =**

DEVIATION OF A GYROSCOPIC TURN INDICATOR CAUSED BY DRY FRICTION [DEVIACE GYROSKOPICKÉHO ZATÁČKOMĚRU ZPŮSOBENÁ SUCHÝM TRENÍM].

Jan Šklíba.

*Zpravodaj VZLÚ*, no. 4, 1964, p. 47-49. In Czech.

Extension of a solution to a linear equation describing the motion of a gyroscopic turn indicator to a more general case in which its axis is subjected to the action of a dry friction moment. A general solution of this equation is obtained which can be used to make a correct choice of parameters of the instrument. The validity of the solution is verified by a complete mathematical induction. J. R.

**A65-20115 =**

HYDROMAGNETIC THEORY FOR SQUEEZE FILMS.

J. B. Shukla (Institute of Higher Technology, Dept. of Mathematics, Khanpur, India).

(American Society of Mechanical Engineers, Lubrication Symposium Cleveland, Ohio, Apr. 28-30, 1964, Paper 64-LubS-12.)

*ASME, Transactions, Series D - Journal of Basic Engineering*, vol. 87, Mar. 1965, p. 142-144.

Discussion of the hydromagnetic theory for squeeze films of conducting lubricants, with special reference to the roller and slipper type of bearings. The effect of magnetic field has been theoretically investigated, and it is shown that the load capacity, pressure, and time of approach can be increased by applying the magnetic field in the system. (Author) M. M.

**A65-20150**

SOLID LUBRICANTS.

John W. Shier and Arthur J. Stock (Acheson Industries, Inc., Acheson Colloids Co., Port Huron, Mich.).

*Product Engineering*, vol. 36, Mar. 29, 1965, p. 66-71.

Description of materials and bonding methods for dry-film lubrication. Dry-film lubricants consist of a thin lubricating film of bonded particles backed up by a hard substrate, and are useful for control surfaces in aircraft and for other inaccessible or clean applications subjected to intermittent motion or loads. Lubricants reviewed are graphite, sulfides, selenides, tellurides, mica, polytetrafluoroethylene (PTFE), PTFE telomers, fluorinated ethylene propylene, chlorinated compounds, and metals. Bonding methods covered are particle-bonding, resin-bonding, and salt-based bonding techniques. P. K.

**A65-20347**

DECOMPOSITION OF HYDROGEN PEROXIDE VAPOUR ON METAL SURFACES AND THE ROLE OF HYDROGEN PEROXIDE IN ATMOSPHERIC CORROSION.

I. L. Roikh, I. P. Bolotich, V. V. Ordynskaia, S. G. Belitskaia, and L. N. Koltunova (Odessa Institute of Technology, Odessa, Ukrainian SSR).

*(Zhurnal Fizicheskoi Khimii)*, vol. 38, June 1964, p. 1588. *Russian Journal of Physical Chemistry*, vol. 38, June 1964, p. 858-860. 10 refs. Translation.

Use of a combination of photographic and optical polarization methods in an investigation of the atmospheric corrosion of magnesium, aluminum, and iron in order to determine the role of hydrogen peroxide in the oxidation of metals. The quantity of  $H_2O_2$  decomposed in the oxidation of these metals was determined as a percentage of the quantity of  $H_2O_2$  formed, and the results were tabulated. A mechanism for the atmospheric corrosion of metals is discussed; it involves the formation of  $H_2O_2$  followed by a stage of combined decomposition and desorption. A relation was obtained between the number of  $Fe_3O_4$  molecules formed and the number of  $H_2O_2$  molecules evolved. D. H.

**A65-20349**

CORROSION OF TITANIUM IN SULPHURIC AND HYDROCHLORIC ACID SOLUTIONS DURING A. C. POLARISATION.

Iu. N. Mikhailovskii (Academy of Sciences, Institute of Physical Chemistry, Moscow, USSR).

*(Zhurnal Fizicheskoi Khimii)*, vol. 38, June 1964, p. 1612. *Russian Journal of Physical Chemistry*, vol. 38, June 1964, p. 873-875. 11 refs. Translation.

Study of the electrochemical and corrosion behavior of titanium in 10 N  $H_2SO_4$  during polarization with a 10-cps ac square-wave. As a result of the recurrent activation of the metal during the cathodic, half-period, vigorous dissolution of titanium takes place in the subsequent anodic half-period. It is found that the maximum corrosion current observed with titanium during ac polarization in  $H_2SO_4$  and HCl solutions is always higher than the current which obtains on dc polarization. This is related to the presence of a slow stage in the formation of the passivating adsorption layer. The amount of titanium dissolving in a single anodic half-period is proportional to the square root of the duration of the half-period. This suggests the presence of a diffusion stage which controls the rate of formation of the passivating adsorption layer. (Author) D. H.

#### A65-20692

##### ELOXAL METHODS IN AIRCRAFT CONSTRUCTION [ELOXAL-VERFAHREN FÜR DEN FLUGZEUGBAU].

Jürgen Weigel (Hamburger Flugzeugbau GmbH, Hamburg, West Germany).

Luftfahrttechnik Raumfahrttechnik, vol. 11, Mar. 1965, p. 77-80. In German.

Description of a technique developed by Hamburger Flugzeugbau GmbH, for covering aluminum or aluminum-alloy aircraft surfaces with an Eloxal layer as a protection against corrosion. In combination with a densification bath, the proposed technique has proved to have alleviated the drawbacks of earlier Eloxal coating methods, arising from thermal, chemical, mechanical, and dynamic loading. The Eloxal layer produced by this technique is corrosion-resistant, ductile, thermochemically stable, and does not crack when the surface is deformed. V. P.

#### A65-21245

##### THE DYNAMICALLY LOADED RADIAL SLIDING BEARING OF ARBITRARY CROSS SECTION [DAS DYNAMISCH BELASTETE RADIAL-GLEITLAGER BELIEBIGEN QUERSCHNITTS].

T. Someya (Karlsruhe, Technische Hochschule, Institut für Maschinen-Konstruktionslehre und Kraftfahrzeugbau, Karlsruhe, West Germany).

Ingenieur-Archiv, vol. 34, no. 1, 1965, p. 7-16. 7 refs. In German. Research supported by the Bundeswirtschaftsministerium and the Forschungsvereinigung Verbrennungskraftmaschinen.

Development of a method for calculating the track curve made by the pivot center point along the play of a cylindrical sliding bearing of arbitrary cross section, for the case of a given time-variable load. It is shown that for the type of bearing considered, a general bearing-clearance function,  $\bar{H}(\varphi)$ , appears in the Reynolds equation for circular cylindrical bearings. The Reynolds equation is solved for the boundary condition of a zero mean oil pressure at the bearing rims. The solution is used to determine the value of the pressure. A system of two differential equations in implicit form is derived for the motion of the pivot center point. The equations are brought to an explicit form by iteration (preferably by computer) and are numerically integrated. The results of the analysis are seen to be of interest to designers of internal combustion engines and turbines. V. P.

#### A65-21650 =

##### HOW SCIENTISTS SEEK TO SAVE BILLIONS OF DOLLARS BY CORROSION RESEARCH.

W. C. Herron (Lockheed Aircraft Corp., Lockheed-Georgia Co., Research Center, Marietta, Ga.).

Lockheed Georgia Quarterly, vol. 2, Spring 1965, p. 8-11, 24.

Discussion of work on methods to protect aircraft from corrosion. Covered are research into the causes of corrosion within integral fuel tanks, stress corrosion, and general stress corrosion mechanisms such as lamellar and exfoliation corrosion. Coating methods for protecting against corrosion are described, including electroplating and vacuum deposition techniques. P. K.

#### A65-21666

##### HOW TO DESIGN FOR CORROSION RESISTANCE.

Norman D. Groves (Carpenter Steel Co., Reading, Pa.).

Machine Design, vol. 37, Apr. 1, 1965, p. 118-122.

Discussion of the design of components for corrosive environments. Corrosive hazards likely to be encountered are considered, and methods for reducing them are described. These methods involve choosing the proper configurations, locations, and tolerances for parts in corrosive environments, and using the proper assembly methods. P. K.

#### A65-21893

##### EFFECTS OF CORROSION ON WAVEGUIDE INSERTION LOSS.

William F. Smith and Thaddeus Sokolowski (Sperry Rand Corp., Sperry Gyroscope Co., Radiation Div., Great Neck, N.Y.).

(Institute of Electrical and Electronics Engineers, International Convention, New York, N.Y., Mar. 22-26, 1965.)

IEEE International Convention Record, vol. 13, pt. 5, 1965, p. 209-216.

Discussion of changes in insertion loss due to the corrosive effects of acidified hydrogen sulfide gas and salt spray on waveguide surfaces. It is noted that the data indicate that insertion loss is affected by the type and amount of corrosion in the waveguide. The conclusion is drawn that the most efficient protective coating will support a stable microwave signal. (Author) M. M.

#### A65-22133

##### CORROSION EXPERIENCE WITH ALUMINUM POWDER PRODUCTS.

J. E. Draley, W. E. Ruther, and S. Greenberg (Argonne National Laboratory, Argonne, Ill.).

International Journal of Powder Metallurgy, vol. 1, Apr. 1965, p. 28-41. 12 refs.

AEC-sponsored research.

Evaluation of extrusions of aluminum-powder products from the standpoint of corrosion resistance to high-temperature (260-350°C) water. Many experimental rod extrusions exhibited corrosion resistance to static 290°C water equivalent to that of wrought alloys. Specimens tested in rapidly flowing water at 315°C exhibited a corrosion rate significantly greater than for the wrought alloy. Several types of impact-extruded tubing were tested. The stronger tubing failed very rapidly; the weaker tubing corroded at the same rate as wrought alloy for about the first 90 days of testing, but suffered extensive localized surface attack and penetration of the corrosion attack along the extrusion direction after prolonged exposure to 290°C water. A precorrosion heat treatment was effective in reducing both types of attack on the weaker tubing. Many samples of tubing extruded through a bridge die performed well during the first months of corrosion exposure. However, all tubes failed on prolonged corrosion in 290°C water. The failure was at one or more of the longitudinal bond lines, formed by the rejoining of the metal streams passing over the mandrel supports in the die during extrusion. Directly extruded tubing also failed on extended exposure to 290°C water. (Author) A. B. K.

#### A65-22208

##### CORROSION.

Henry Leidheiser, Jr. (Virginia Institute for Scientific Research, Richmond, Va.).

Chemical and Engineering News, vol. 43, Apr. 5, 1965, p. 78-92.

Discussion of research on, and problems associated with, corrosion. Studies on the mechanism of corrosion, on thin films, thin-film reactions, thin-film inactivity, and methods for inhibiting corrosion are discussed. Corrosion problems reviewed include stress-corrosion cracking, cavitation damage, hydrogen embrittlement, the low-temperature oxidation of intermetallic compounds, and corrosion caused by bacteria, as in jet aircraft fuel tanks. The establishment of an Institute of Corrosion Control is discussed. P. K.

#### A65-22215

##### CONTROL TESTS TO VERIFY HIGH RESISTANCE TO STRESS CORROSION OF 7075-T73 ALLOY PRODUCTS.

W. King, B. W. Lifka, and L. A. Willey (Aluminum Company of America, Alcoa Research Laboratories, New Kensington, Pa.).

Materials Evaluation, vol. 23, Feb. 1965, p. 89-95.

Description of rapid screening methods for determining if 7075 aluminum alloys meet the stress-corrosion cracking stipulations incorporated into military specifications for T73 tempered alloy products. In these specifications, a specimen taken in the

## A65-22234

transverse or short transverse direction from a 7075-T73 product stressed to within 75% of the guaranteed yield strength must not fail in a 30-day exposure to 3.5% NaCl solution in which it is periodically immersed. Because this test is lengthy, two rapid screening techniques were developed. One involves a solution-potential method, and the other an electrical-conductivity procedure. Both methods indicate within hours if a given specimen meets the quality for 7075-T73 material. P. K.

## A65-22234 #

LUBRICATION OIL IN AVIATION [MAZACÍ OLEJ V LETECTVÍ].  
Jan Krotky.

*Zpravodaj VZLÚ*, no. 6, 1964, p. 51-53. 11 refs. In Czech.

Discussion of the problems in the development of lubrication oils, especially for turboprop engines. Classes of materials are presented which are suitable for the development of chemical lubricants corresponding to current aviation requirements. The state of the art in Czechoslovakia is also considered. M. L.

## A65-22351

AN INTEGRATED THEORY OF STRESS CORROSION.  
K. C. Thomas and R. J. Allio (Westinghouse Electric Corp., Atomic Power Div., Pittsburgh, Pa.).

*Nature*, vol. 206, Apr. 3, 1965, p. 82, 83. 7 refs.

Presentation of a theory of stress corrosion as a basis for developing an overall model for stress corrosion from which the effect of cation and anion in solution on susceptibility to stress corrosion cracking may be predicted. The concept of short-range order is introduced to explain the apparently anomalous stress corrosion resistance of "Incoloy 800" (high stacking fault energy and a planar dislocation arrangement) and nichrome (planar arrangement). It is postulated that in the higher nickel alloys short-range order is present which on deformation leads to a planar structure in spite of a high stacking fault energy; thus the disorder on the slip planes created by the passage of dislocations results in chemically reactive sites on the surface. The results of some recent investigations by Bergen are reviewed in which it was found that chloride in the oxide film on 304 stainless migrates up a temperature gradient and that the migration is reversible as the stress is removed. It is proposed that the chloride stress corrosion susceptibility is controlled by both the dislocation structure and the chloride migration capacity of the oxide film. The concept of short-range order is required to explain the formation of a planar grouping of dislocations in a high stacking fault energy alloy. Thus it is concluded that Incoloy 800 and nichrome are not susceptible to stress corrosion failure because there are sufficient nickel ions in the oxide film to prevent chloride migration to the high-stress regions on the surface. M. L.

## A65-22363

THE NITRIC ACID-OXYGEN REDOX ELECTRODE IN ACID ELECTROLYTE.

Joseph A. Shropshire and Barry L. Tarmy (Esso Research and Engineering Co., Linden, N. J.).

IN: FUEL CELL SYSTEMS (Advances in Chemistry Series, 47). Symposia sponsored by the American Chemical Society, Division of Fuel Chemistry. Washington, American Chemical Society, 1965, p. 153-165. 9 refs. Contract No. DA-36-039 SC-89156.

Study of the performance and mechanism of a fuel cell oxygen cathode, using low concentrations of nitric acid as a redox intermediate in sulfuric acid. Electrode performance using either carbon or noble metal electrodes is superior to that attainable by direct electrochemical reduction of oxygen or air in acid solution. Mechanism studies showed that the reaction is autocatalytic with the actual electrochemical reaction being the reduction of nitrous acid to nitric oxide and the rate-limiting step involving the chemical reduction of nitric acid with nitric oxide. Regeneration of nitric acid by oxidation of nitric oxide and subsequent hydrolysis of nitrogen dioxide proceeds at rates that would require 0.1 lb/kwh of nitric acid in actual fuel cell operation on air. (Author) D. P. F.

## A65-22368

ANODIC OXIDATION OF DERIVATIVES OF METHANE, ETHANE, AND PROPANE IN AQUEOUS ELECTROLYTES. I - GALVANOSTATIC INVESTIGATIONS.

H. Binder, A. Köhling, H. Krupp, K. Richter, and G. Sandstedt (Battelle-Institut, Frankfurt, West Germany).

IN: FUEL CELL SYSTEMS (Advances in Chemistry Series, 47). Symposia sponsored by the American Chemical Society, Division of Fuel Chemistry.

Washington, American Chemical Society, 1965, p. 269-282. 9 refs.

Research supported by the Robert Bosch GmbH.

Galvanostatic measurements of anodic potential-current density plots of a Raney platinum electrode with alcohols, aldehydes, ketones, and carboxylic acids up to 800 mv (vs hydrogen electrode in the same solution). These measurements were made at temperatures of 25° and 80°C, the electrolyte being 5N potassium hydroxide and 5N sulfuric acid. Acetic acid and propionic acid cannot be oxidized in potassium hydroxide solution, but are active in sulfuric acid. With methanol, ethanol, glycol, and glycerol in 5N potassium hydroxide at 200 ma per cm<sup>2</sup> potentials of from 300 mv to 350 mv were observed, while in 5N sulfuric acid the potentials range from 500 to 650 mv under the same conditions. D. P. F.

## A65-22369

ANODIC OXIDATION OF DERIVATIVES OF METHANE, ETHANE, AND PROPANE IN AQUEOUS ELECTROLYTES. II - COULOMETRIC-POTENTIOSTATIC INVESTIGATIONS.

H. Binder, A. Köhling, and G. Sandstedt (Battelle-Institut, Frankfurt, West Germany).

IN: FUEL CELL SYSTEMS (Advances in Chemistry Series, 47). Symposia sponsored by the American Chemical Society, Division of Fuel Chemistry.

Washington, American Chemical Society, 1965, p. 283-291. 10 refs.

Research supported by the Robert Bosch GmbH.

Coulometric-potentiostatic measurements showing that in alkaline solutions, using Raney platinum as a catalyst, only the derivatives of methane can be oxidized completely to carbonate and water. With derivatives of ethane and propane oxidation stops at the stage of the carboxylic acid. In sulfuric acid all derivatives investigated can be oxidized completely to carbon dioxide at 80°C, if provisions are made to prevent loss of volatile intermediates. From the results of methanol in sulfuric acid it may be concluded that on the Raney platinum electrodes at +700 mv, the oxidation of methanol is diffusion-controlled only at concentrations smaller than 0.3 mole per liter. (Author) D. P. F.

## A65-22370

OXIDATION OF OLEFINS AND PARAFFINS IN LOW TEMPERATURE FUEL CELLS.

M. J. Schlatter (California Research Corp., Richmond, Calif.).

IN: FUEL CELL SYSTEMS (Advances in Chemistry Series, 47). Symposia sponsored by the American Chemical Society, Division of Fuel Chemistry.

Washington, American Chemical Society, 1965, p. 292-317. 8 refs.

Army-ARPA-supported research.

Complete oxidation of low molecular weight paraffins and olefins at platinized porous carbon anodes in low temperature acid electrolyte fuel cells. These two classes of hydrocarbons do, however, show substantial differences in electrochemical behavior. The paraffin-depolarized electrodes are readily poisoned by air or oxygen; olefin depolarized electrodes are much less affected. The paraffins are said to give more favorable cell voltages at low currents but to fall off badly under load. The olefins can support high currents as the anode potential approaches that of the oxygen electrode. (Author) D. P. F.

## A65-22744

MATERIALS FOR LUBRICATED SYSTEMS.

F. J. Clauss and W. C. Young (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).

IN: SPACE MATERIALS HANDBOOK.

Edited by C. G. Goetzl, J. B. Rittenhouse, and J. B. Singletary. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1965, p. 209-296. 123 refs.

Discussion of lubricants and self-lubricating materials for use in advanced spacecraft systems. The requirements for lubrication

materials used in space are reviewed, and the mechanisms of hydrodynamic and boundary lubrication are described. The properties, characteristics, and performance in simulated space environments of various lubrication materials are discussed. These materials include oils and greases, graphite,  $\text{MoS}_2$ ,  $\text{MoS}_2$  films,  $\text{FeS}_2$ -impregnated solids,  $\text{MoS}_2$ -added oils and other carriers,  $\text{PbO}$ , soft metals, plastics, fluorocarbon resins, nylons, ceramics, and cermets.

P. K.

**A65-22788****MICROTOPOGRAPHY OF FINELY GROUND STEEL SURFACES IN RELATION TO CONTACT AND WEAR.**

A. Dorinson (Sinclair Research, Inc., Harvey, Ill.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-15.)

ASLE Transactions, vol. 8, Apr. 1965, p. 100-107; Discussion, J. A. Greenwood (Burndy Corp., Norwalk, Conn.), p. 107, 108; Author's Closure, p. 108. 14 refs.

Research supported by Sinclair Research, Inc.

Results of interferometric examination and taper sectioning to elucidate the microtopography of the contacting surfaces of a finely ground disk and a conically ended rider. The question of the real area of contact when these surfaces are put together under high pressure is considered. It is found that after a short period of rubbing, with either a white or compounded oil, the visible evidence of true metal-to-metal contact is quite sparse in comparison to the potential real area of contact deduced from microtopographical considerations. The scar on the end of the rider, on the other hand, is found to show evidence of extensive rubbing, as a consequence of the high ratio of the area of the disk track to the area on the end of the rider. It is found that when an indifferent lubricant is used in high-pressure wear experiments, the first worn-off material detected with any certainty consists of obviously secondary agglomerates of primary wear material. The adhesion of these agglomerates to the rubbing surface of the disk is shown to radically alter the nature of the surface, so that any analysis of contact based on the initial topography of the disk and the rider is no longer valid. It is concluded that an effective extreme-pressure lubricant, on the other hand, tends to preserve the initial topography of the contacting surfaces. Thus, the action of extreme-pressure lubricants is found to be intimately connected with changes in surface topography due to wear and the influence of these changes on further wear.

M. L.

**A65-22789****THE FRICTION AND WEAR BEHAVIOR OF MOLYBDENUM-TUNGSTEN-CHROMIUM ALLOYS IN HIGH-TEMPERATURE SODIUM ENVIRONMENTS.**

W. H. Roberts (United Kingdom Atomic Energy Authority, Reactor Development Laboratory, Risley, Lancs., England).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-25.)

ASLE Transactions, vol. 8, Apr. 1965, p. 109-121; Discussion, W. A. Glaeser (Battelle Memorial Institute, Columbus, Ohio), p. 121, 122; Author's Closure, p. 122. 22 refs.

Study of wear data and friction coefficients of molybdenum-tungsten-chromium alloys in the presence of liquid sodium and sodium vapor and argon. Data are obtained with a crossed-cylinders apparatus over a range of 200-500°C. Comparisons are made with results obtained in gaseous environments of pure argon, helium, and carbon dioxide. The effect of increasing the oxygen content of liquid sodium from 5 to 80 ppm on friction and wear behavior is indicated. It is shown that chemisorbed double-oxide films, formed by the reaction of the molybdenum, tungsten, and chromium alloys with the sodium environment, play a significant role in providing boundary lubrication in high-temperature sodium. It is found that the availability of oxygen is an essential feature of the reactions for producing the double oxides in sodium. It is concluded that the molybdenum and tungsten double oxides are not thermodynamically stable in high-purity sodium at high temperatures (above 400°C), but that sodium-chromium complexes can be effective to quite high temperatures. The effectiveness of the lubrication provided by such films is found to be a function of the specific nature of the sodium environment and temperature, as well as time at temperature.

M. L.

**A65-22791****FRICTION AND CLEAVAGE OF LAMELLAR SOLIDS IN ULTRA-HIGH VACUUM.**

D. G. Flom, A. J. Haltner, and C. A. Gaulin (General Electric Co., Missile and Space Div., Space Sciences Laboratory, Philadelphia, Pa.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-18.)

ASLE Transactions, vol. 8, Apr. 1965, p. 133-144; Discussion, H. E. Evans (NASA, Goddard Space Flight Center, Greenbelt, Md.) and C. E. Vest (Midwest Research Institute, Kansas City, Mo.), p. 144, 145; Authors' Closure, p. 145. 32 refs.

Contract No. AF 33(657)-10493.

Presentation of results of measurements of sliding friction on copper surfaces at  $10^{-6}$  to  $10^{-9}$  torr for five lamellar solids, namely, molybdenum sulfide, tungsten sulfide, cadmium iodide, bismuth iodide, and phthalocyanine. No evidence is found that the sliding behavior of any of these materials is improved by the presence of gas or vapors. Each is found to evolve considerable quantities of gas during sliding. Molybdenite and surface-nucleated pyrolytic graphite are cleaved in an ultrahigh vacuum apparatus built for this purpose. The graphite specimens are tested in both as-deposited and annealed forms. It is found that the predominant gas given off for the former is methane, while for the latter, it is water vapor. In the cleavage of molybdenite, the primary gas is found to be methane.

(Author) M. L.

**A65-22792****LUBRICATION BY TRANSFERRED FILMS OF SOLID LUBRICANTS.**

J. K. Lancaster (Ministry of Aviation, Royal Aircraft Establishment, Farnborough, Hants., England).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-19.)

ASLE Transactions, vol. 8, Apr. 1965, p. 146-153; Discussion, Paul H. Bowen (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.), p. 154; Author's Closure, p. 154, 155. 22 refs.

Experimental study of the feasibility of providing a continuous supply of solid lubricant to a metal (steel) by transfer from a compact. Friction and wear measurements are made on a pin sliding against a rotating disk, with a compact of solid lubricant, particularly graphite and molybdenum disulfide, which is independently loaded against the disk in the same track as the pin. It is found that the amount of lubricant depends markedly on the surface finish of the steel and that the most effective lubricant films form on relatively rough surfaces. It appears that film-to-substrate bonding is primarily mechanical. Determinations are made of the scuffing load and endurance tests which show that replenishment of the lubricant film by continuous transfer is possible only to a limited extent. With molybdenum disulfide, the film is found to ultimately wear away, but with graphite, failure is found to occur when the mean surface temperature exceeds about 100°C. It is concluded that the load-carrying capacity of transferred molybdenum disulfide films is appreciably greater than that of graphite films.

M. L.

**A65-22793****ON THE MECHANISMS OF  $\text{MoS}_2$ -FILM FAILURE IN SLIDING FRICTION.**

A. W. J. de Gee (Metal Research Institute TNO, Physico-Mechanical Dept., Delft, Netherlands), G. Salomon (Centraal Laboratorium TNO, Delft, Netherlands), and J. H. Zaat (Eindhoven, Technological University, Eindhoven, Netherlands).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-30.)

ASLE Transactions, vol. 8, Apr. 1965, p. 156-162; Discussion, M. B. Peterson (Mechanical Technology, Inc., Latham, N.Y.) and H. F. Barry (Climax Molybdenum Company of Michigan, Detroit, Mich.), p. 162, 163; Authors' Closure, p. 163. 8 refs.

Research sponsored by Alpha Molykote Corp., Molykote Produktionsgesellschaft mbH, and Molykote S.A.R.L.

Study of the effect of oxygen on the life expectancy of a run-in molybdenum disulfide film under heavy load. Tested in argon, with only small quantities of oxygen present, the smooth running period is found to be increased by at least two decades as compared to a test in oxygen. Blister formation is seen to be an important factor

in the gradual destruction of the lubricant film. Blisters of sub-microscopic size can be traced with the electron microscope. In the presence of oxygen, macroscopic blisters are seen to be formed rapidly. Oxygen promotes sintering of the individual particles to a continuous, smooth, and therefore highly reflective lubricant layer. No wear occurs during the smooth running period of  $\text{MoS}_2$  lubrication. Graphite differs from  $\text{MoS}_2$  in this respect and in its much lower load-carrying capacity. A cine-film on graphite-lubricated surfaces shows a rougher surface and the formation of smaller blisters. On addition of graphite to  $\text{MoS}_2$ , a sudden change in surface features is seen to occur within narrow limits of graphite concentration. It is concluded that the addition of 15% by weight of graphite increases the total life expectancy of the  $\text{MoS}_2$  film, but reduces the length of the smooth running period. (Author) M. L.

#### A65-22794

##### THE EFFECTS OF LOAD ON THE FRICTIONAL PROPERTIES OF MOLYBDENUM DISULFIDE.

S. A. Karpe (U.S. Navy, Marine Engineering Laboratory, Friction and Wear Div., Annapolis, Md.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-21.)

ASLE Transactions, vol. 8, Apr. 1965, p. 164-174; Discussion, Martin J. Devine (U.S. Naval Air Engineering Center, Philadelphia, Pa.), Josef Gänsemeier (Molykote Produktionsgesellschaft mbH, Munich, West Germany), G. Salomon, and A. W. J. de Gee (Centraal Laboratorium TNO, Delft, Netherlands), p. 174-176; Authors' Closure, p. 176-178. 29 refs.

Determination of the kinetic coefficient of friction for several grades of commercially available molybdenum disulfide powder. The powders are individually applied to separate steel-supporting substrates to form a thin lubricant film. Friction measurements are made at loads of 0.1 to 10 kg and at a slow speed of sliding. It is shown that the coefficient of friction decreased with increasing load, contrary to Amontons' second law. A theory is postulated to explain the observed variation in the friction coefficient with load. It is concluded that this variation could be explained solely on the basis of the macroelastic and/or macroelastic and plastic deformation characteristics of the supporting substrates. (Author) M. L.

#### A65-22795

##### SOME ILLUSTRATIVE PROBLEMS IN THE FLOW OF VISCO-ELASTIC NON-NEWTONIAN LUBRICANTS.

R. I. Tanner (Sydney, University, Dept. of Mechanical Engineering, Sydney, Australia).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-10.)

ASLE Transactions, vol. 8, Apr. 1965, p. 179-182; Discussion, J. K. Appeldoorn (Esso Research and Engineering Co., Linden, N.J.), p. 182; Authors' Closure, p. 183. 16 refs.

Discussion of the factors affecting the choice of an equation of state for the description of non-Newtonian viscoelastic lubricants. Simple solutions for squeeze films with and without superimposed steady shears are given. These illustrate the complexity of the action of these fluids, including the variation of the effective relaxation time and the "softening" of the film under dynamic loading. (Author) M. L.

#### A65-22797

##### SLIDER BEARING PERFORMANCE WITH A NON-NEWTONIAN LUBRICANT.

Y. C. Hsu (Southwest Research Institute, San Antonio, Tex.) and Edward Saibel (Rensselaer Polytechnic Institute, Dept. of Mechanics, Troy, N.Y.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-17.)

ASLE Transactions, vol. 8, Apr. 1965, p. 191-194.

Analysis of a method capable of approximating the behavior of a slider bearing without side leakage, using a non-Newtonian fluid. An example of this method is given, and it is found to be relatively easy to apply and valid for a large range of strain rates. The difference between this treatment and earlier ones is found to be in

the type of constitutive equations used. This treatment satisfies the invariant condition and is considered applicable to both pseudo-plastic and dilatant fluids. The pressure distribution, oil flow, and friction force are calculated, and the results are compared with the corresponding ones for a Newtonian fluid. M. L.

#### A65-22965 \*

##### INVESTIGATION OF ROLLING FRICTION IN CYLINDRICAL BODIES [ISSLEDOVANIYE TRENIIA PRI VNUTRENNEM KACHENII TSILINDRICHESKIKH TEL].

V. D. Rabko.

Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskikh Nauk, no. 3, 1964, p. 135-141. 11 refs. In Russian.

Investigation of the effect of rolling rate, load and specific pressure, lubrication, material, and the radii of curvature on the rolling friction of cylindrical bodies. At 11 to 70-kg loads, the rolling friction coefficient is found to increase with rolling rate, specific pressure, the radius of the cylinder, and the amount of the lubricant. A pendulum device, proposed by Kunin and the author and described in a previous paper, is used in the experiments. A line drawing of the device is given and the experimental procedure is described. V. Z.

#### A65-23318 \*

##### EVALUATION OF DRY FILM LUBRICATING MATERIALS FOR SPACECRAFT APPLICATIONS.

Harold E. Evans, Charles E. Vest, and Bowden W. Ward (NASA, Goddard Space Flight Center, Advanced Technical Development Section, Greenbelt, Md.).

IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, STRUCTURES AND MATERIALS CONFERENCE, 6TH, PALM SPRINGS, CALIF., APRIL 5-7, 1965. [A65-23300 13-32] New York, American Institute of Aeronautics and Astronautics, 1965, p. 185-191.

Investigation of solid film lubricating materials for aerospace application. Intensive investigation of various lubricating materials and systems revealed that  $\text{MoS}_2$  and Teflon come very close to meeting the aerospace requirements of low coefficient of friction, low vapor pressure, capability of replenishing the film, and low wear rate. An evaluation of  $\text{MoS}_2$  powders,  $\text{MoS}_2$  and Au compacts, Duroid ( $\text{MoS}_2$ -PTFE) and  $\text{MoS}_2$  in situ established the merits of these materials for vacuum operation. For rolling applications, such as occur in a ball bearing, a fully machined ball retainer of 60% Teflon, 40% glass fiber +  $\text{MoS}_2$  shows the best results. Examples of radial loads, speeds, and operating time, respectively, are as follows: (R-2 bearing) 0.8 oz., 8000 rpm, 4380 hours; 2.1 oz., 1800 rpm, 1700 hours; (R-4 bearing) 4.5 lb, 10 rpm, 10,515 hours all at  $10^{-8}$  torr pressure. In special cases where rolling element lubrication must be accomplished while a conductive electrical path must be maintained, the directly applied  $\text{MoS}_2$  can be used. This may be accomplished by the "in situ" process or by burnishing  $\text{MoS}_2$  powder on the specimen. Wear life can be enhanced and electrical noise kept low by using  $\text{MoS}_2$ -Au compacts to act as a film-replenishing source, such as in ball retainer applications. (Author) M. M.

#### A65-23440

##### EFFECT OF ZIRCONIUM ON THE CORROSION RESISTANCE OF STEEL.

V. S. Kovalenko and E. L. Zats (Donets Scientific Research Institute of Ferrous Metallurgy, Ukrainian SSR).

(Metallovedenie i Termicheskaya Obrabotka Metallov, Apr. 1964, p. 30, 31.) Metal Science and Heat Treatment, Mar.-Apr. 1964, p. 223, 224. Translation.

Investigation of carbon steel alloyed with varying amounts of Si, Mn, S, P, and Zr in order to determine the effect of the latter on the corrosion resistance. It was considered that the effect of the alloyed solid solution (anodic phase) and the formation of Zr inclusions (cathodic phase) must be taken into account. It was found that: (1) the corrosion resistance of carbon steel in water is increased by the addition of 0.10 to 0.16% Zr, (2) the increase of the corrosion resistance of steel containing Zr is due to the decrease of the activity of the anodic process resulting from the increase

of the thermodynamic stability of the anodic phase or its passivation, and (3) the effect of Zr on the cathodic process manifests itself in the formation of a large number of microcathodes which do not affect the corrosion rate. F. R. L.

#### A65-23447 #

##### SULFUR AND SEA SALT ATTACK OF TURBINE BLADES.

C. A. Dalton (Bristol Siddeley Engines, Ltd., Parkside, War., England).

American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Washington, D.C., Feb. 28-Mar. 4, 1965, Paper 65-GTP-7, 6 p.

Members, \$0.50; nonmembers, \$1.00.

Discussion of the effects, mechanism, and prevention of sulfur attack in aero engines. The mechanism for sea salt attack on marine turbine blades is proposed, and the results of tests designed to cure the trouble are presented. The treatment suggested is said to be only a palliative, and speculation on future work for greater protection is included. (Author) M.M.

#### A65-23464 #

##### NONLINEAR BENDING OF A STRESS CORROSION SPECIMEN.

Paul E. Wilson and Edward E. Spier (General Dynamics Corp., General Dynamics/Astronautics, Structures Research Group, San Diego, Calif.).

American Society of Mechanical Engineers, Aviation and Space Conference, Los Angeles, Calif., Mar. 14-18, 1965, Paper 65-AV-3, 6 p. 10 refs.

Members, \$0.50; nonmembers, \$1.00.

Analysis of the postbuckling behavior of an initially straight plate strip of variable flexural rigidity whose ends are subjected to opposing "axial" loads. Bending action takes place only in the center section of the strip, since the symmetric end portions are considered to be rigid. Pertinent postbuckling load-deflection curves are deduced by using the nonlinear bending theory of a plate strip, and the maximum stress is obtained as a function of the half-distance between the loaded ends. Numerical results are presented in nondimensional form, and the theoretical solution is shown to compare favorably with a major portion of the experimental stress and deflection data. (Author) A. B. K.

#### A65-23501

##### LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM, UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963, PROCEEDINGS.

Edited by D. Muster and B. Sternlicht (Mechanical Technology, Inc., Latham, N. Y.).

Symposium supported by AEC, NASA, NSF, and Navy. Berkeley, McGutchan Publishing Corp., 1965. 974 p. \$20.

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THEORY OF TURBULENT LUBRICATION. V. N. Constantinescu (Rumanian Academy, Bucharest, Rumania), p. 153-213. 42 refs. [See A65-23503 13-15]

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EXTERNALLY PRESSURIZED BEARING LUBRICATION. W. A. Gross (Ampex Corp., Redwood City, Calif.), p. 307-421. 147 refs. [See A65-23506 13-15]

INERTIA EFFECTS IN SELF-ACTING BEARING LUBRICATION THEORY. A. A. Milne (Department of Scientific and Industrial Research, East Kilbride, Scotland), p. 423-527. 53 refs. [See A65-23507 13-15]

INFLUENCE OF BEARINGS ON ROTOR BEHAVIOR. Beno Sternlicht (Mechanical Technology, Inc., Latham, N. Y.), p. 529-699. 218 refs. [See A65-23508 13-15]

FRICTION AND WEAR. D. Tabor (Cambridge, University, Cambridge, England), p. 701-761. [See A65-23509 13-15]

THERMAL EFFECTS AND ELASTO-KINETICS IN SELF-ACTING BEARING LUBRICATION. Georg Vogelpohl (Max-Planck-Institut für Strömungsforschung, Göttingen, West Germany), p. 763-822.

GAS LUBRICATED BEARINGS. J. Stanley Ausman (Litton Systems, Inc., Woodland Hills, Calif.), p. 825-853. 14 refs. [See A65-23510 13-15]

DESIGN OF FLUID FILM HYDRODYNAMIC AND HYDROSTATIC THRUST AND JOURNAL BEARINGS. Dudley D. Fuller (Columbia University, New York, N. Y.), p. 855-877.

COMPUTER ANALYSIS OF HIGH-DUTY ROLLING-ELEMENT BEARING SYSTEMS. A. Burton Jones, p. 879-903. [See A65-23511 13-15]

LUBRICATION IN THE ENVIRONMENT OF SPACE. Paul Lewis (Mechanical Technology, Inc., Latham, N. Y.), p. 905-939. 17 refs. [See A65-23512 13-15]

HIGH-TEMPERATURE LUBRICATION. Marshall B. Peterson (Mechanical Technology, Inc., Latham, N. Y.), p. 941-974. 67 refs. [See A65-23513 13-15]

#### A65-23502

##### INVERSE PROBLEMS IN HYDRODYNAMIC LUBRICATION AND DESIGN DIRECTIVES FOR LUBRICATED FLEXIBLE SURFACES. H. Blok (Delft, University, Delft, Netherlands).

IN: LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM, UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963, PROCEEDINGS. [A65-23501 13-15]

Edited by D. Muster and B. Sternlicht.

Symposium supported by AEC, NASA, NSF, and Navy.

Berkeley, McGutchan Publishing Corp., 1965, p. 1-151. 62 refs.

Outline and exemplification of the "inverse" variant of the theory of hydrodynamic lubrication. Problems in hydrodynamic lubrication, in contrast to the classical ones, are defined as "inverse" when a given distribution of film pressures is imposed upon the film, the profile of the film hydrodynamically compatible with that distribution being required. The treatment is mainly confined to problems where the effects of the finite width may be neglected, and the then plane flow in the film may be assumed incompressible and isothermal, and to be influenced only by hydrodynamic wedging action. In this type of inverse problem the pertinent Reynolds equation becomes a cubic, with film thickness as the unknown. The only complication lies in the fact that, unless some suitable restrictive condition is imposed upon the film pressure distribution, and also one on the film profile, an indeterminacy will arise in that the solution comprises an entire family of admissible film profiles. Thus a limiting possibility exists for the film profile to become vanishingly thin. It is shown that, for any normal design purpose, full control over the entire film profile is not really necessary, provided the determinacy of the profile is ensured, and that the magnitude of the "flow criterion" is determined. The control over the film profile has to be effected through suitably shaping the distribution of the film pressures, or the distribution of the contact pressures that would arise at the same given load and for no lubricant supply at all. Because the two pressure distributions cannot be made identical, and their distribution may overridingly affect the control required, the deviations must in turn be kept under control. It is shown how to accomplish this through contouring and elastically designing the rubbing surfaces in such a way that the distribution of the contact pressure is "straight flanked." Several simple problems illustrative of inverse theory are worked out, and the relationship between the profile of flexible coatings, the contour of the opposite, rigid, rubbing surface, and the deformation characteristics of such coatings is assessed. Remarks are made on certain more complicated inverse problems. F. R. L.

#### A65-23504

##### THIN FILM LUBRICATION.

D. Dowson (Leeds, University, Leeds, England).

IN: LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM, UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963, PROCEEDINGS. [A65-23501 13-15]

## A65-23505

Edited by D. Muster and B. Sternlicht.

Symposium supported by AEC, NASA, NSF, and Navy.

Berkeley, McGutchan Publishing Corp., 1965, p. 215-281. 41 refs.

Discussion of the very thin but coherent oil films which occur in an envisaged geometry of two cylinders in contact along a generator. In such contacts very high pressures are generated within the thin film of lubricant which separates the solid components, and the thin film is distinguished from the classical hydrodynamic lubrication problem by (1) the influence of pressure upon lubricant viscosity, and (2) the effect of elastic distortion of the bounding solids. When the bounding solids deform elastically under high contact pressures the shape of the oil film is changed. This in turn modifies the distribution of pressure, and the subject is complex since solutions must simultaneously satisfy the basic equations of lubrication and elasticity. It is considered that the most important question in thin film lubrication is the prediction of film thickness in highly loaded elastic contacts. F. R. L.

## A65-23505

### BOUNDARY LUBRICATION.

D. Godfrey (California Research Corp., Richmond, Calif.).

IN: LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM,

UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963,

PROCEEDINGS. [A65-23501 13-15]

Edited by D. Muster and B. Sternlicht.

Symposium supported by AEC, NASA, NSF, and Navy.

Berkeley, McGutchan Publishing Corp., 1965, p. 283-306. 18 refs.

Discussion of the formation of films and their effects in a sliding mechanism, with exact definition of common terms. The various degrees of boundary lubrication are related to the physical properties of the films. Among the common terms, film strength is considered the most descriptive because films provide lubrication and because to be effective they must possess the strength to resist penetration by an asperity. Physically adsorbed films, films of adsorbed polar molecules, and films bonded to surfaces by chemical reactions are discussed in detail, with examples from research and practice. The film-forming mechanism is treated separately. Interfacial material, or films that affect boundary lubrication in an oil system are described, beginning with physically adsorbed films with the least film strength, followed by chemisorbed films with moderate film strength, and chemical reaction films with the greatest film strength. It is shown that, generally, film strength in boundary lubrication is determined by the melting point of the film. F. R. L.

## A65-23509

### FRICITION AND WEAR.

D. Tabor (Cambridge, University, Cambridge, England).

IN: LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM,

UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963,

PROCEEDINGS. [A65-23501 13-15]

Edited by D. Muster and B. Sternlicht.

Symposium supported by AEC, NASA, NSF, and Navy.

Berkeley, McGutchan Publishing Corp., 1965, p. 701-761.

Discussion of some of the basic ideas on friction and wear. Sliding friction is considered to be mainly due to adhesion which occurs over the region of real contact. A smaller part of the friction arises from the deformation of the surfaces. It is shown that these processes can explain most of the phenomena observed in the sliding friction of metals and nonmetals, in rolling friction, and in the wear of rubbing surfaces. Some of the more recent methods that have been developed for studying the topography of a surface, its structure, and chemical composition, such as electron microscopy, are discussed. The effect of asperities in determining the true area of contact is examined for metals and nonmetals, followed by review of the laws of friction and methods of measuring it. The mechanism of metallic friction, the friction and adhesion of clean metals, the friction of brittle solids and polymers, the surface temperature of sliding solids, rolling friction and deformation losses, and the mechanisms of wear are given detailed attention. F. R. L.

## A65-23512

### LUBRICATION IN THE ENVIRONMENT OF SPACE.

Paul Lewis (Mechanical Technology, Inc., Latham, N. Y.).

IN: LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM,

UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963,

PROCEEDINGS. [A65-23501 13-15]

Edited by D. Muster and B. Sternlicht.

Symposium supported by AEC, NASA, NSF, and Navy.

Berkeley, McGutchan Publishing Corp., 1965, p. 905-939. 17 refs.

Results of an experimental program to investigate lubrication problems, and to aid in selecting lubricants for devices and equipment which must operate in the environment of space, with citations of the work of other investigators. Those effects of the environment which would affect bearing system performance are examined in detail. Laboratory simulation for evaporation and for dry materials is discussed, and an evaluation of fluid lubricants (oils and greases) is made. The test apparatus, designed to provide (1) pressures of  $10^{-5}$  mm Hg, (2) a condensing surface which views the evaporating sample, and (3) a means for agitation to prevent stratification and thermal gradients is described. Various tests carried out on liquid lubricants of different classes, and on different classes of greases are discussed. The use of solid lubricants is considered. Their important properties and operating parameters are reviewed, and some test results are presented. F. R. L.

## A65-23513

### HIGH-TEMPERATURE LUBRICATION.

Marshall B. Peterson (Mechanical Technology, Inc., Latham,

N. Y.).

IN: LUBRICATION AND WEAR, INTERNATIONAL SYMPOSIUM,

UNIVERSITY OF HOUSTON, HOUSTON, TEX., JUNE 1963,

PROCEEDINGS. [A65-23501 13-15]

Edited by D. Muster and B. Sternlicht.

Symposium supported by AEC, NASA, NSF, and Navy.

Berkeley, McGutchan Publishing Corp., 1965, p. 941-974. 67 refs.

Investigation of high-temperature lubrication, considered to be lubrication at temperatures above which present synthetic lubricants cannot be used (above  $\pm 700^\circ\text{F}$ ). Primary emphasis is placed on the materials and lubricants which are available, and literature is cited to point out the approaches which have been used in high-temperature lubrication. The subject is discussed with reference to the dry sliding characteristics of the materials themselves, and various material combinations under various conditions are examined. Solid lubricants receive detailed attention, and the characteristics of various materials (e.g., graphite, and certain sulfides and oxides) are reviewed. The means which have been devised for practical use of solid lubricants are (1) solid films, (2) gas reaction films, (3) filled reservoirs, (4) stick lubrication, and (5) gas-solid circulation. Glass lubricants, liquid metal lubricants, and lubrication with gas are considered. F. R. L.

## A65-23538 \*

THE EFFECT OF CORROSION ON THE PERFORMANCE OF THIN-FILM CAPACITORS WITH SILICON OXIDE AND ALUMINUM OXIDE DIELECTRIC [DER EINFLUSS DER KORROSION AUF DIE ZUVERLÄSSIGKEIT VON DÜNNSCHICHTKONDENSATOREN MIT SILIZIUMOXID UND ALUMINIUMOXID DIELEKTRIKA].

András Csányi, Tamás Strausz, and György Wollitzer (Forschungsinstitut für die nachrichtentechnische Industrie, Budapest, Hungary).

IN: RELIABILITY IN ELECTRONICS [ZUVERLÄSSIGKEIT IN DER ELEKTRONIK], PROCEEDINGS OF THE WISSENSCHAFTLICHER VEREIN FÜR NACHRICHTENTECHNIK, UNGARISCHE AKADEMIE DER WISSENSCHAFTEN, ABTEILUNG FÜR TECHNISCHE WISSENSCHAFTEN, UND REGIERUNGSAUSSCHUSS FÜR TECHNISCHE ENTWICKLUNG, SYMPOSIUM, BUDAPEST, HUNGARY, OCTOBER 27-29, 1964. VOLUME 1, SECTION A. [A65-23537 13-09]

Budapest, Haus der Technik, 1964. 12 p. 5 refs. In German.

A discussion of the factors affecting the performance and reliability characteristics of thin-film capacitors. These factors can be divided into three classes, namely, the metallic mounting, the ability of the capacitor to recover from momentary peak voltages, and the reliability factor of the terminals. Aluminum has proved to be the most suitable material for the mountings, as it is easily applied by vaporization techniques, but the zone where this aluminum is joined to the silver terminals is the region where

intermetallic corrosion occurs, in many cases rendering the capacitor useless. Experiments have proven that this corrosion is caused by moisture, which can be avoided by not using the customary silvering mixture which contains the impurities which give rise to the corrosion. Virtually corrosion-free capacitors were obtained by using a special silvering preparation, inverting the normal order of vaporizing the aluminum onto the silver, and subjecting the glass substrate plates to a special technique. D. P. F.

#### A65-23565 #

INVESTIGATION OF THE ANTIFRICTION PROPERTIES OF SOLIDS AT HIGH TEMPERATURE IN VACUUM AND IN SOME GASEOUS MEDIA [ISSLEDOVANIIE ANTIFRIKTSIONNYKH SVOISTV TVERDYKH TEL PRI VYSOKIKH TEMPERATURAKH V VAKUUME I NEKOTORYKH GAZOVYKH SREDAKH].

A. P. Semenov and V. V. Pozdnyakov (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Mashinovedeniia, USSR).

Akademiia Nauk SSSR, Doklady, vol. 160, Feb. 1, 1965, p. 811-814. In Russian.

Investigation of friction and adhesion (at a 5-kg total load and 0.8-mm/min sliding rate) of graphite materials, Cr, Ti, Mo, W, and Nb carbides, and some borides and oxides at temperatures to 2000°C in vacuum and argon, helium, and nitrogen media. An experimental high-frequency ( $10^{-4}$  to  $10^{-5}$  mm Hg) vacuum oven is developed which permits the investigation of (1) friction in isothermal conditions and at rising and falling temperatures, (2) adhesion and mechanical properties, and (3) sintering and chemical contact interaction of samples. The procedure is described, and the results are discussed. V. Z.

#### A65-23826 #

A WEDGE-FLOW APPROACH TO LUBRICATION THEORY.

W. E. Langlois (International Business Machines Corp., San José, Calif.).

Quarterly of Applied Mathematics, vol. 23, Apr. 1965, p. 39-46. Contract No. Nonr-3448(00).

Discussion of a theory of fluid-film lubrication developed from an assumption of local wedge-flow, rather than local parallel-channel flow. This leads to a generalization of the Reynolds lubrication equation governing the pressure. A refinement of the lubrication theory does not necessarily follow: unlike the parallel-channel case, the stress field may differ significantly from an isotropic pressure, so that imposing ambient conditions on the bearing periphery does not always yield boundary conditions for the pressure equation. It is noted that, if the bearing slope differs appreciably from zero only in the film interior, consistent boundary conditions are once more available. (Author) M. M.

#### A65-23936 #

EFFECT OF COLD WORKING ON STRESS-CORROSION CRACKING OF STAINLESS STEEL.

Tatsuo Maekawa, Masaru Kagawa, and Nobuo Nakajima (Mitsubishi Atomic Power Industries, Inc., Engineering and Research Laboratory, Saitama, Japan).

(Japan Institute of Metals, Journal, vol. 27, 1963, p. 548.)

Japan Institute of Metals, Transactions, vol. 5, Oct. 1964, p. 219-224. 9 refs. Translation.

Investigation of the effect of cold working on the sensitivity of several austenitic stainless steels of AISI Type 304 and 304L to stress-corrosion cracking in a high-temperature NaCl solution (300°C, 500 ppm Cl<sup>-</sup>), and in a boiling 42% MgCl<sub>2</sub> solution. It was found that (1) the carbon content and heat treatment before cold working do not appreciably affect the sensitivity of stainless steel to stress-corrosion cracking in the high-temperature NaCl solution and (2) the degree of cold working does not seem to have a direct relation to the sensitivity of stainless steel to stress-corrosion cracking in the high-temperature NaCl solution and in the boiling 42% MgCl<sub>2</sub> solution. However, the ferrite transformed from the austenite by cold working significantly decreases the sensitivity of stainless steel to stress-corrosion cracking in both solutions.

(Author) D. H.

#### A65-24115 #

FUNDAMENTAL STUDY OF A GOLD PLATING AND DRY FILM LUBRICANT SYSTEM FOR LONG LIFE SLIDING ELECTRIC CONTACTS.

L. P. Solos (Amphenol-Borg Electronics Corp., Broadview, Ill.). IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, DAYTON, OHIO, MAY 11-13, 1964, PROCEEDINGS. [A65-24101 13-09]

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1964, p. 117-123.

Investigation of the design factors associated with sliding-contact friction and wear. Various contact design principles are reviewed and are used to develop a functional model to simulate the half-million repetitive cycles of contact life and other requirements for the sliding contact of a coaxial microwave cavity line. An acid gold plating over a rhodium plating, coated with a thin Teflon lubricant film, is found to possess exceptional wear properties for extensive cycling. The mechanisms affecting dynamic contact resistance (or noise) are discussed. P. K.

#### A65-24242

DEVELOPMENTS IN HIGH-TEMPERATURE ULTRAHIGH-VACUUM FRICTION STUDIES.

L. G. Kellogg (North American Aviation, Inc., Atomic International Div., Canoga Park, Calif.).

American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 6A1. 11 p. 13 refs. Members, \$0.60; nonmembers, \$1.20.

Review of studies on the bearing compatibility of various materials for aerospace nuclear reactors. A total of 67 pairs of materials were tested in sliding couple at pressures down to  $10^{-9}$  torr and temperatures up to 1300°F. The material combinations covered were metal-metal, both with and without dry lubricant; metal-carbon; ceramic-ceramic, both with and without dry lubricant; metal-ceramic; and ceramic-carbon pairs. Data are presented which illustrate the effects of vacuum on sliding friction and on surface film formation. The results indicate that carbon graphites and Na<sub>2</sub>SiO<sub>3</sub> bonded dry-film lubricants provide relatively low friction when coupled with Al<sub>2</sub>O<sub>3</sub> (flame-sprayed) surfaces. P. K.

#### A65-24245

NEW SOLID LUBRICANTS - PREPARATION, PROPERTIES AND POTENTIALS.

D. J. Boes (Westinghouse Electric Corp., Research Laboratory, Pittsburgh, Pa.).

American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 5C3. 26 p. 11 refs. Members, \$0.60; nonmembers, \$1.20.

Review of studies on the physical and chemical properties of a group of layer-lattice compounds similar in crystal structure to MoS<sub>2</sub> and graphite and suitable for use as aerospace solid lubricants. The compounds treated are the dichalcogenides (disulfides, diselenides, and ditellurides) of the Group V-B and VI-B metals molybdenum, tungsten, niobium, and tantalum. The friction characteristics, volume resistivity, thermal and oxidative stability, radiation resistance, and combined cryogenic and high vacuum capabilities of these lubricants are evaluated. It is found that the combined lubricity, electrical conductivity, radiation resistance and high-vacuum capability exhibited by these compounds make them attractive candidates for aerospace solid lubricants. The primary limitation is the restriction of 400-450°C that must be placed on their use in oxidizing atmospheres. P. K.

#### A65-24248

THE EFFECTS OF REACTOR RADIATION ON THREE HIGH-TEMPERATURE SOLID-FILM LUBRICANTS.



## A65-24249

R. H. McDaniel (General Dynamics Corp., Nuclear Aerospace Research Facility, Fort Worth, Tex.).  
American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 5C4. 30 p. 11 refs.

Members, \$0.60; nonmembers, \$1.20.

Contract No. AF 29(601)-6213.

Study of the effects of irradiation and temperature on the wear-life characteristics of solid-film lubricants for aerospace applications. Lubricants studied were: (1) a PbS-MoS<sub>2</sub>-B<sub>2</sub>O<sub>3</sub> combination on steel and on nickel-base alloy substrates and (2) CaF<sub>2</sub>-oxide frit and MoS<sub>2</sub>-graphite-sodium silicate formulations on nickel-base substrates. Test specimens were irradiated with gamma rays and neutrons from a thermal reactor and subjected to sliding-wear tests at temperatures up to 1500°F. The data are analyzed through the use of statistical procedures using Weibull plots. P.K.

## A65-24249

FLUORIDE SOLID LUBRICANTS FOR EXTREME TEMPERATURES AND CORROSIVE ENVIRONMENTS.

Harold E. Sliney, Thomas N. Strom, and Gordon P. Allen (NASA, Lewis Research Center, Cleveland, Ohio).  
American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 5C5. 31 p. 11 refs. Members, \$0.60; nonmembers, \$1.20.

Review of studies on the chemical and thermal stability of various fluoride solid lubricants under extreme environmental conditions. Thermochemical considerations were used to select chemically stable metal fluorides which would be capable of functioning in aerospace environments, and the fluoride coatings chosen were bonded to Ni-Cr alloys and tested. Measurements were made on the friction, wear, and endurance properties of ceramic-bonded calcium fluoride in air from 80° to 1900°F and in liquid sodium at 1000°F and on the lubricating properties of fused fluoride coatings in hydrogen and air to 1500°F and in sodium at 1000°F. The results demonstrate the suitability of fluoride coatings under these conditions. P.K.

## A65-24250

LUBRICANT FILM THICKNESS AND WEAR IN ROLLING POINT CONTACT.

T. E. Tallian, J. I. McCool, L. B. Sibley (SKF Industries, Inc., Engineering and Research Center, King of Prussia, Pa.), and E. F. Brady (Pennsylvania Military College, Chester, Pa.).  
American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 4A4. 45 p. 14 refs.

Members, \$0.60; nonmembers, \$1.20.

Contract No. NOW 61-0716-c.

Review of measurements on elastohydrodynamic effects in rolling contact phenomena. Lubricant film thickness in the partial elastohydrodynamic range was measured as a function of speed in a rolling four-ball configuration for four mineral oils, two esters, and a polyphenylester, covering a viscosity range of 8 to 360 cs. Film thickness is shown to vary exponentially with speed. At the point where a full elastohydrodynamic film is formed, the product of viscosity and speed is constant for most lubricants. The wear rate after run-in is found to equal the total area of asperity contact multiplied by a constant which is a characteristic of the lubricant. The compounded ester type lubricants are found to be best for wear prevention. The size and shape of wear particles are studied, and the results suggest they are shaped like platelets. P.K.

## A65-24252

ON THE DETERMINATION OF FRICTION FORCES IN TURBULENT LUBRICATION.

V. N. Constantinescu (Rumanian Academy, Institute of Applied Mechanics, Hydrodynamic Lubrication Laboratory; Bucharest, Polytechnic Institute, Bucharest, Rumania) and S. Galetuse (Bucharest, Polytechnic Institute, Bucharest, Rumania).  
American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 3A1. 31 p. 12 refs. Members, \$0.60; nonmembers, \$1.20.

Analysis, using the mixing-length hypothesis, of the friction forces in turbulent lubricating films. The friction stresses on the

two lubricated surfaces in contact and their dependence on Reynolds number and on pressure distribution are studied. Formulas are obtained for the friction stresses which are valid for small and moderate variations of the film thickness and are applied to calculate friction forces and torques in journal bearings and slider bearings. P.K.

## A65-24256

A REFINED SOLUTION TO THE THERMAL-ELASTO-HYDRO-DYNAMIC LUBRICATION OF ROLLING AND SLIDING CYLINDERS.

H. S. Cheng (Mechanical Technology, Inc., Latham, N.Y.).  
American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 4A2. 34 p. 18 refs.

Members, \$0.60; nonmembers, \$1.20.

Navy-supported research.

Extension, through a more rigorous analysis, of a recent theoretical study by Cheng and Sternlicht of the thermal-elasto-hydrodynamic lubrication of rolling and sliding cylinders. The previous work is extended by (1) removing the assumption of a mean viscosity across the thickness of the lubricating film, (2) using a two-dimensional finite-difference approach to calculate the temperature field in the film, (3) replacing the exponential relation between the density and the pressure by a more realistic empirical function, and (4) calculating the rolling and sliding friction forces. The results show that temperature has a moderate effect on the shape of the pressure and film profile, but has very little effect on the magnitude of the film thickness in the contact zone. The frictional force, however, is strongly influenced by the temperature rise in the film. The results are compared with experimental measurements. P.K.

## A65-24258

INFLUENCE OF SURFACE ROUGHNESS ON BOUNDARY FRICTION.

Yukio Miyakawa (National Aerospace Laboratory, Tokyo, Japan).  
American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 6A2. 9 p. 7 refs. Members, \$0.60; nonmembers, \$1.20.

Experimental study, for various loads, speeds, and lubricants, of the effect of surface roughness on boundary friction. Hardened steel surfaces, polished with wet chromic oxide and with various grades of emery paper and lubricated with various mixtures of a highly refined spindle oil and oleic acid, were used. It is found that the friction when sliding parallel to the direction of polishing is greater than that when sliding perpendicular to this direction. The degree of roughness has little influence on the friction, except for extremely small or large degrees of roughness. The effective lubrication occurs as a result of the interruption by the surface roughness of contact. Therefore, the most effective lubrication takes place when the sliding surface is perpendicular to the direction of polishing and the surface has an appropriate degree of roughness. The effects of surface roughness on friction-load and friction-speed characteristics are also considered. P.K.

## A65-25442 #

CONTACT TEMPERATURES IN ROLLING/SLIDING SURFACES.

A. Cameron (London, University, Imperial College of Science and Technology, Dept. of Mechanical Engineering, London, England), A. N. Gordon, and G. T. Symm (London, University Imperial College of Science and Technology, Dept. of Mathematics, London, England).

Royal Society (London), Proceedings, Series A, vol. 286, May 25, 1965, p. 45-61. 6 refs.

Discussion of three related but separate problems concerning the surface temperatures of frictional contacts. The first part considers the surface temperatures of two rolling/sliding contacts when the condition is imposed that there must be no temperature discontinuity over the contact zone, for a range of surface speeds such that  $V_1/V_2$  varies between +1 and -1. The second part studies the surface temperatures when a rectangular heat source moves over the surfaces at various speeds. As the speeds increase the asymptotic expression for the temperature becomes more accurate. The third section considers the way the surface temperatures build up when (1) the contact is repeated, and (2) heat is convected from the free surface. (Author) D. P. F.

**A65-25479 =**

HYDRODYNAMICS OF A NONISOTHERMAL LUBRICATING FILM [K GIDRODINAMIKE NEIZOTERMICHESKOGO SMAZOCHNOGO SLOIA].

M. E. Podol'skii.

*Akademii Nauk SSSR, Izvestia, Mekhanika*, Mar.-Apr. 1965, p. 26-32. 6 refs. In Russian.

Discussion of the thermal boundary conditions for parallel-surface thrust bearings. Approximate integration of the hydrodynamic and energy-balance equations for a film of constant thickness leads to a solution which shows that variation of viscosity with temperature results in the onset of negative pressures in the film. This finding does not agree with the results obtained by Zienkiewicz and by Cameron.

V. P.

**A65-25497**

A FIVE-POINT PROGRAM DESIGNED TO ELIMINATE CONTAMINATION AND CORROSION OF FUEL TANKS ON AIRCRAFT USING JET TURBINE FUEL.

Wilburn A. Boggs (Lockheed Aircraft Corp., Lockheed-Georgia Co., Marietta, Ga.).

IN: SOCIETY OF AUTOMOTIVE ENGINEERS, BUSINESS AIRCRAFT CONFERENCE, WICHITA, KAN., MAY 6-8, 1965, PROCEEDINGS. [A65-25495 15-02]

New York, Society of Automotive Engineers, 1965, p. 11-18. 13 refs.

General discussion of the problems resulting from the introduction of contaminated jet turbine fuel into integral fuel tanks, with presentation of a five-point program designed to eliminate the contamination problem. The frequency of contamination and the seriousness of the problem have greatly increased. Contributing factors are the increase in volume of fuel handled and changes brought about by bulk handling, the difference in physical characteristics of the fuel, the proliferation of microbiological growth in "water bottoms," and failure of industry fully to understand the importance of the problem. The five-point program consists of (1) continuous scavenging of free water from storage tanks; (2) use of a suitable fuel biocide; (3) adoption of an improved finish system for aircraft tanks which is resistant to contaminated fuel; (4) use of a water-sensitive portable filter system as a final filter when receiving fuel from an uncontrolled source; and (5) regular inspection of the integral fuel tanks, with additional inspections after refuelling from uncontrolled sources.

F. R. L.

**A65-25505**

ADDITIONAL DESIGN PERFORMANCE AND GROWTH POTENTIAL THROUGH THE USE OF A SYNTHETIC LUBRICANT.

Reginald S. Shearer (Lehigh Chemical Co., Chestertown, Md.).

IN: SOCIETY OF AUTOMOTIVE ENGINEERS, BUSINESS AIRCRAFT CONFERENCE, WICHITA, KAN., MAY 6-8, 1965, PROCEEDINGS. [A65-25495 15-02]

New York, Society of Automotive Engineers, 1965, p. 110-114.

Discussion of improvements in service performance permitted by synthetic lubricants, compounded organic esters. Cooperation is needed from all segments of the aircraft industry, including the lubricant manufacturer, to achieve the maximum in aircraft design and utilization. It is considered that utilization of synthetic lubricants will make it possible to eliminate the oil cooler (thus permitting weight and cost savings) and to increase engine compression ratio for better power-to-weight ratio.

F. R. L.

**A65-25545 =**

INVESTIGATION OF A METHOD OF COMPENSATING FOR THE FRICTION IN THE SHAFT BEARINGS OF INSTRUMENTS [ISSLEDOVANIE ODNOGO METODA KOMPENSATSII TRENIIA V OPORAKH VALOV PRIBOROV].

B. A. Komashinskii.

*Priborostroyeniye*, vol. 8, no. 2, 1965, p. 107-112. In Russian.

Investigation of a method of reducing mechanical losses due to friction by means of "forced" motion of the outer races of a ball bearing. The races of the first and second bearing moved in opposite direction at an angular velocity much higher than that of the axle. The test stand used in the experiments is described, and the effectiveness of the method is assessed for several modes of forced motion and various angular velocities. The method is found to yield the best results in the case of dry friction and "pullout" friction on starting the axle.

V. P.

**A65-25642**

TFE-LUBRICATED PHENOLICS.

David P. Willis, Jr. (Whitford Chemical Corp., Malvern, Pa.).

*Machine Design*, vol. 37, May 27, 1965, p. 130-137.

General discussion of modified phenolic molding compounds containing polytetrafluoroethylene (TFE) and a description of test data which indicate advantageous applications for such compounds. Velocities of up to 1200 rpm are tolerable; there is an optimum surface smoothness for film formation and hence minimum wear rates; proper break-in lubrication appreciably affects bearing life. The factors affecting bearing design are discussed, and the comparative properties of several bearing materials are summarized in tables. TFE-lubricated phenolic bearings can operate in temperature ranges from 350 to -40°F. The coefficient of friction decreases as the load increases, up to about 10,000 psi. Advantages to be derived from the use of such TFE-lubricated resins include lack of contaminating lubricant, "squeakless" dry operation, permanent internal lubrication, high heat capability, light weight, dimensional stability, low wear, and excellent frictional properties.

D. P. F.

**A65-25644**

GRAPHICAL METHOD FOR FINDING OPTIMUM BEARING SPAN FOR OVERHUNG SHAFTS.

T. Terman and J. G. Bollinger (Wisconsin, University, Madison, Wis.).

*Machine Design*, vol. 37, May 27, 1965, p. 159-162.

Description of a tabular technique for optimizing the bearing span with respect to reducing shaft bending and bearing deflection to a minimum. The design approach may involve three fundamental situations: (1) a preliminary design of a shaft may be completed in which the selection of dimensions and bearings is based on boundary conditions, and in this case redesign optimization can proceed; or (2) a design may be synthesized by first choosing the proportional distribution of the cross-sectional variation between bearings; or (3) for a fixed span, bearing stiffnesses or shaft diameters may be altered until the given bearing span is optimum. The strain-energy method which is described and illustrated by graphs differs from the usual method in which weighted average moment of inertia is used for finding optimum bearing span. The use of elastic strain-energy principles to find the bending deflection of a nonuniform shaft takes into account the actual cross-section distribution. The displacement at the load caused by deflection at the bearings is the same as that determined for a uniform shaft, but the expression for the bending deflection is different.

D. P. F.

**A65-25992**

FLEXURE-PIVOT BEARINGS. 1 - SPRING RATE, BEARING TYPES, SINGLE-STRIP DESIGN.

Warren D. Weinstein (Sperry Rand Corp., Sperry Gyroscope Co., Inertial Div., Great Neck, N. Y.).

*Machine Design*, vol. 37, June 10, 1965, p. 150-157.

Examination of types of flexure-pivot bearings, their spring rate, and the design of single-strip bearings. Bearings of this type are made of one or more strips of an elastic material rigidly attached to two moving parts. The pivot-bearing assembly constrains one part to move in a particular manner with respect to the other. Inherent advantages of such bearings include low cost, no static friction, low hysteresis, and no lubricant requirement. They are rigid about the nonsensitive axis and the spring rate about the sensitive axis can be controlled. Their main disadvantage is their inability to provide large angles of rotation between the parts they connect. Flexure-pivot bearings can be designed quickly by means of dimensionless curves once the major bearing parameters have been specified. These include: (1) spring rate or torsional gradient, (2) size, (3) environment, (4) angular motion required, and (5) loading.

F. R. L.

**A65-26059**

ESTIMATING CYCLICAL LIFE FOR EQUIPMENT EXPERIENCING ONLY WEAROUT FAILURES.

## A65-26089

J. E. Comer (Gulton Industries, Inc., Engineered Magnetics Div., Hawthorne, Calif.).

IN: ACTIVE RELIABILITY; ANNUAL WEST COAST RELIABILITY SYMPOSIUM, 6TH, UNIVERSITY OF CALIFORNIA, LOS ANGELES, CALIF., FEBRUARY 20, 1965. [A65-26051 15-15]

Symposium sponsored by the Reliability Div. of the Los Angeles Section, American Society for Quality Control, and the College of Engineering and University Extension, University of California, North Hollywood, Western Periodicals Co., 1965, p. 133-146.

Calculation of an approximate lifetime requirement to serve as a guide for arranging a program of reliability testing for any individual part failing primarily by wearout. It is assumed on the basis of experience that the distribution of the failure rate about the wearout point is Gaussian, and that the effect of random failures is negligible. Formulas are developed which make it possible to calculate minimum average lifetimes. F. R. L.

## A65-26089 \*

ON THE POSSIBILITY OF REALIZING A NONHOLONOMIC CONSTRAINT BY MEANS OF VISCOUS FRICTION FORCES. N. A. Fufaev.

(Prikladnaia Matematika i Mekhanika, vol. 28, May-June 1964, p. 513-515.)

PMM - Journal of Applied Mathematics and Mechanics, vol. 28, no. 3, 1964, p. 630-632. Translation.

Analysis using Chaplygin's sledge to show that nonholonomic coupling can be achieved by means of viscous-friction forces in the limiting case where the coefficient of viscous friction is equal to infinity. The results refute Caratheodory's conclusion of the impossibility of such a realization.

## A65-26262

EFFECTS OF THE SPACE VACUUM ON METALS.

L. J. Bonis (Likon Corp., Natick, Mass.).

Space/Aeronautics, vol. 43, June 1965, p. 76, 78, 80, 82, 84.

Consideration of some of the special factors that determine the characteristics of a metal in the space vacuum. The absence of adsorbed gases on the surface of a metal is seen to make the metal less vulnerable to crack propagation. Successful simulation of vacuum effects on metals is said to require the use of ultrahigh vacuum simulators capable of ultimate pressures as low as  $10^{-12}$  torr. For pressures not lower than  $10^{-6}$  to  $10^{-7}$  torr the experimental data on evaporation and sublimation are said to be in good agreement with the Langmuir equation. The absence of boundary layers on a vehicle moving through outer space is shown to lead to the phenomenon of sputtering. The special lubrication requirements imposed by the space vacuum are pointed out. Molybdenum disulfide, tungsten disulfide, and soft metals such as gold are said to have given good results as space lubricants. Certain common elastomers are also said to be stable in high vacuums. A. B. K.

## A65-26487

STRESS RELIEVING TITANIUM ALLOY WELDMENTS IN VACUUM.

Herschel R. Green, Jr. (North American Aviation, Inc., Columbus Div., Columbus, Ohio).

Metal Progress, vol. 87, Apr. 1965, p. 72-75.

Description of the welding and heat-treatment cycle required for forming certain wing sections of the A-5 Vigilante out of an alpha-titanium alloy. It is shown that, in order to prevent contamination by halogens and other impurities, welded parts made of this alloy must be stress-relieved in vacuum. The furnaces used for this operation are described, as well as certain problems which arose when they were first put into operation. A. B. K.

## A65-26490

WEAR AND FRICTION OF SOLID SURFACES.

William A. Glaeser (Battelle Memorial Institute, Columbus, Ohio).

Metal Progress, vol. 87, Apr. 1965, p. 146, 148, 150, 152, 154, 156, 158.

Review of reports given at the 1964 ASME-ASLE International Lubrication Conference. The reports presented deal with: the

influence of crystal-lattice structure on wear and friction phenomena; the effects of penetration hardness, elastic modulus, and work-hardening characteristics on resistance to abrasive wear; the importance of surface effects - such as adsorption, true area of contact, and thin-film lubrication - in boundary lubrication; wear and frictional behavior of various metal alloys in liquid sodium; solid lubricants which form thin films when rubbed on metal surfaces; and materials for high-temperature bearings. A number of theories of lubrication mechanisms are presented, along with evaluations of effects of rolling contact fatigue on ceramics and cermets. A. B. K.

## A65-26503 \*

INITIAL PHASES OF DAMAGE TO TEST SPECIMENS IN A CAVITATING VENTURI.

F. G. Hammitt, L. L. Barinka, M. J. Robinson, R. D. Pehlke, and C. A. Siebert (Michigan, University, Nuclear Engineering Dept., Laboratory for Fluid Flow and Heat Transport Phenomena, Ann Arbor, Mich.).

(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64-WA/FE-2.)

ASME, Transactions, Series D - Journal of Basic Engineering, vol. 87, June 1965, p. 453-463; Discussion, J. Z. Lichtman (U.S. Naval Applied Science Laboratory, Brooklyn, N.Y.).

p. 463; Authors' Closure, p. 463, 464. 12 refs.

Research supported by United Aircraft Corp. and NASA.

Pictorially illustrated discussion of the detailed characteristics of pitting in the early phases of cavitation damage incurred by test specimens inserted into the diffusing portion of a cavitating venturi. The characteristics are discussed in terms of the degree of cavitation, fluid, material, duration, and velocity effects. Quantitative damage results are presented from these tests for mercury and water as test fluids and for a variety of test materials. Various possible damage correlating parameters are discussed and examined. (Author) D. H.

## A65-26533 \*

THE INFLUENCE OF OIL FILM ON KINETOSTATIC CONTACT STRESSES [WPŁYW WARSTWY OLEJU NA KINETOSTATYCZNE NAPRĘŻENIA KONTAKTOWE].

Jacek Stupnicki.

Archiwum Budowy Maszyn, vol. 12, no. 1, 1965, p. 47-66. 15 refs. In Polish.

Theoretical and experimental investigation aimed at determining whether the equations in the theory of elasticity for cylinders in dry contact may be used to describe the pressure distribution at the contact points of ball and roller bearings in the presence of a lubricating film. The effect of the film is studied by photoelastic techniques, using plastic and glass models at pressures of 400 and 3000 kg/cm<sup>2</sup>, respectively. Using the isochromatic curves, the pressure distribution at the contact surface of two cylinders is calculated on a computer by the method of characteristics. The results of the investigation indicate that the lubricating film between two cylinders has the effect of decreasing by about 20% the values for the contact stresses obtained from the Hertz equations. This effect increases in proportion to the initial viscosity of the film. The effect of the film on the contact stresses is influenced only by rolling rates up to 6 m/sec; at rolling rates higher than 6 m/sec, the effect remains constant. V. P.

## A65-26568

INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR CONVENTION, 3RD, LONDON, ENGLAND, MAY 27-29, 1965.

London, Institution of Mechanical Engineers, 1965. 213 p \$9.10.

### CONTENTS:

CONTACT STRESSES IN FLAT ELLIPTICAL CONTACT SURFACES WHICH SUPPORT RADIAL AND SHEARING FORCES DURING ROLLING. D. J. Haines (Bristol, University, Bristol, England), p. 1-12. 10 refs. [See A65-26569 16-15]

EFFECT OF LUBRICANTS ON THE FATIGUE OF STEEL AND OTHER METALS. G. D. Galvin and H. Naylor (Shell Research, Ltd., Chester, England), p. 23-37. 19 refs. [See A65-26570 16-15]

ROLE OF WEAR DEBRIS IN THE WEAR CHARACTERISTICS OF A ROLLING ELEMENT SUBJECTED TO TANGENTIAL SURFACE TRACTIONS. S. N. Giolmas and J. Halling (Liverpool, University, Liverpool, England), p. 107-115. 12 refs. [See A65-26571 16-15]

EFFECT OF GEOMETRIC CONFORMITY BETWEEN ROLLING BODIES ON THE SLIP AND WEAR IN THE CONTACT REGION. B. G. Brothers and J. Halling (Liverpool, University, Liverpool, England), p. 203-213. 12 refs. [See A65-26572 16-15]

#### A65-26570

EFFECT OF LUBRICANTS ON THE FATIGUE OF STEEL AND OTHER METALS.

G. D. Galvin and H. Naylor (Shell Research, Ltd., Thornton Research Centre, Chester, England).

IN: INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR CONVENTION, 3RD, LONDON, ENGLAND, MAY 27-29, 1965. [A65-26568 16-15]

London, Institution of Mechanical Engineers, 1965, p. 23-37. 19 refs.

Employment of a simple rotating cantilever fatigue rig in tests (1) to see if lubricants have any effects on the fatigue lives of steel and other metals, (2) to investigate the nature of any effects found, and (3) to advance the general knowledge concerning the effect of noncorrosive environments on the fatigue of metals. It has been shown that mineral oils, synthetic lubricants, and additives used in lubricants can indeed affect the fatigue lives of steel and other reactive metals; at stresses above the fatigue limits, large effects are observed. Specimen lives may be only 10 to 20% of those found in MWO (medicinal white oil, a solvent-refined oil subsequently treated with oleum to remove polar and aromatic materials), but in most fluids lives are at least as long as those measured in tests carried out in air. The largest reduction in fatigue limit was about 13%. The effect which the apparently noncorrosive fluids have is either to accelerate the propagation of fatigue cracks initiated by repeated stressing but to play no part in the initiation of fatigue cracks, or to accelerate both the initiation and propagation of fatigue cracks. In both crack initiation and crack propagation the fluid must be capable of reacting chemically with the metal specimens or with the oxide layer on the specimen. Chemically unreactive metals such as gold and platinum are unaffected by such fluids and this suggests that if a suitable hard unreactive plating were found it might alleviate pitting in situations where the lubricant was thought to be having a deleterious effect.

W.M.R.

#### A65-26571

ROLE OF WEAR DEBRIS IN THE WEAR CHARACTERISTICS OF A ROLLING ELEMENT SUBJECTED TO TANGENTIAL SURFACE TRACTIONS.

S. N. Giolmas and J. Halling (Liverpool, University, Dept. of Mechanical Engineering, Liverpool, England).

IN: INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR CONVENTION, 3RD, LONDON, ENGLAND, MAY 27-29, 1965. [A65-26568 16-15]

London, Institution of Mechanical Engineers, 1965, p. 107-115. 12 refs.

Research supported by the United Kingdom Atomic Energy Authority.

Description of some slow-speed rolling experiments in which wear was produced by microslip in the contact zone. It was found that after an interval of time the wear rate increased if the experiment was designed to restrict the escape of wear debris. This increased wear rate was suppressed in experiments where the loose debris was removed at frequent intervals during the test. The wear measurements were obtained using radioactive tracer techniques and clearly demonstrate some material firmly attached to the mating surface. The increased wear rate was also suppressed for tests carried out in a nitrogen atmosphere. These results thus confirm a rolling-wear process of a similar type to that described by Kerridge for sliding wear.

(Author) W.M.R.

#### A65-26572

EFFECT OF GEOMETRIC CONFORMITY BETWEEN ROLLING BODIES ON THE SLIP AND WEAR IN THE CONTACT REGION.

B. G. Brothers and J. Halling (Liverpool, University, Dept. of Mechanical Engineering, Liverpool, England).

IN: INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR CONVENTION, 3RD, LONDON, ENGLAND, MAY 27-29, 1965. [A65-26568 16-15]

London, Institution of Mechanical Engineers, 1965, p. 203-213. 12 refs.

Research supported by the United Kingdom Atomic Energy Authority.

Illustration, using model techniques, of the small-scale slip processes that occur between a rolling element and its track. These slip mechanisms arise from the applied loading and the geometric conformity of the system. Creep measurements arising from such slip are presented and compared with theoretical predictions. The wear resulting from the slip is determined using the radioactive tracer technique and is shown to correlate with the creep measurements. Analysis of the distribution of the transferred metal substantiates the assumed mechanism. The nature of the wear process in this type of situation is discussed and shown to have practical significance in the design of rolling-contact systems.

(Author) W.M.R.

#### A65-26662

THE EFFECT OF DRY AND FLUID LUBRICATION ON INSTRUMENT BALL BEARING TORQUES AT HIGH SPEED.

H. H. Mabie (Sandia Corp., Albuquerque, N. Mex.).

Lubrication Engineering, vol. 21, June 1965, p. 242-249.

Results of high-speed torque tests run on R2, R3, and R4 ball bearings lubricated with MIL-L-6085A oil and MIL-G-3278A grease. Bearings of the same sizes were also tested with PTFE retainers impregnated with MoS<sub>2</sub>. These tests were conducted over a speed range of 1000 to 40,000 rpm at room temperature with one radial load for a given bearing size. Tests were also run at a constant speed of 10,000 rpm on the grease- and oil-lubricated bearings for 60 minutes to determine the effect of time upon torque. Sample standard deviations were calculated for each data point for all of the tests. The results of the tests are presented graphically with the plus and minus value of the sample standard deviation shown for each point.

(Author) A.B.K.

#### A65-26951

MACHINING STAINLESS STEEL.

P. H. Frederick and D. G. Klingensmith (Allegheny Ludlum Steel Corp., Bar Products Div., Pittsburgh, Pa.).

Product Engineering, vol. 36, May 24, 1965, p. 56-63.

Discussion of improvements in the machining and machinability of stainless-steel alloys. The machinability of 416 EZ, 303 EZ, and 203 EZ is compared with that of B-1112, the recognized standard for comparison. Improvements in machine tools, cutting tools, and lubrications are described, and cost and availability data for several stainless-steel alloys are presented.

S.H.B.

#### A65-26973 #

CONTRIBUTION TO THE STUDY OF STAINLESS STEELS USING POTENTIODYNAMIC CURVES [PŘÍSPĚVEK KE STUDIU NEREZÁVĚJÍCÍCH OCELÍ S POUŽITÍM POTENCIODYNAMICKÝCH KŘIVEK].

Rudolf Štefec.

Hutnické Listy, vol. 20, May 1965, p. 345-347. 16 refs. In Czech.

Investigation of the effect of heat treatment on the corrosion resistance of the chromium stainless steel ČSN 17023. The steel samples were hardened and then tempered at different temperatures up to 700°C. It is shown that tempering at temperatures near 500°C and at higher temperatures causes a narrowing of the passivity region and a lowering of the corrosion resistance in the active state. Using potentiodynamic curves, it is shown that the

corrosion resistance minimum occurs after tempering at temperatures near 500°C. The mechanism of the lowering of the corrosion resistance is considered. The study shows that tempering at temperatures higher than 500°C results in a partial improvement of the corrosion resistance. This is explained by the chromium entering from chromium carbide into the solid solution. It is also noted that the rise of the temperature of the corroding solution increases the critical current density required for passivation; that the characteristics of the potentiodynamic curves also depend on the method used for preparing the surface of the electrode and on the duration of the immersion of the electrode in the corroding solution before the curve is registered. M. L.

**A65-27161 #**

**FUELS AND LUBRICANTS FOR THE NEXT GENERATION AIRCRAFT - THE SUPERSONIC TRANSPORT.**  
W. G. Dukek (Esso Research and Engineering Co., Linden, N.J.).  
*Esso Air World*, vol. 17, Mar.-Apr. 1965, p. 119-125. 13 refs.

Consideration of the problem of providing satisfactory fuels and lubricants for the next generation of transport aircraft, where the root of the problem is the tendency of hydrocarbons and esters to undergo high-temperature oxidation in the supersonic environment. It is noted that an understanding of the chemistry of auto-oxidation has made it possible to process fuels to remove reactive species, to synthesize ester lubricants of a more thermally stable molecular structure, and to provide the anti-oxidants, metal de-activators, and other additives useful for maintaining the life of these improved products. The best of current aviation kerosenes and a new Type-II lubricant are ready to serve the first-generation Mach 2 to 2.5 SST. Advanced SSTs of the Mach 3 class will demand better fuels and oils of the improved Type-II or Type-III categories. Such products are in active development. (Author) M. M.

**A65-27311**

**DESIGN AND MANUFACTURE OF AN APPARATUS FOR RESEARCH ON PRESSURE-LUBRICATED FLAT-FACE THRUST BEARINGS [PROGETTO E COSTRUZIONE DI UNA ATTREZZATURA PER RICERCHE SU CUSCINETTI DI SPINTA A LUBRIFICAZIONE FORZATA].**  
Giorgio Bartolozzi (Pisa, Università, Istituto di Macchine, Pisa, Italy).

*Ingegneria Meccanica*, July 1964, p. 3-16. 10 refs. In Italian.

Description of the design of an apparatus suitable for carrying out a series of tests to establish criteria for the optimum sizing of pressure-lubricated parallel flat-face thrust bearings. Comments are offered on the setting up and mode of utilization of the equipment during a first series of tests. The results obtained are reported. M. M.

**A65-27345**

**IMPROVEMENT OF THE SCALE-RESISTANCE OF HEAT-RESISTANT MATERIALS BY INTRADIFFUSION OF METALS [VERBESSERUNG DER ZUNDERBESTÄNDIGKEIT HOCHWARM-FESTER WERKSTOFFE DURCH EINDIFFUSION VON METALLEN].**  
Albert von den Steinen and Gottfried Becker (Deutsche Edelstahlwerk AG, Forschungsinstitut, Krefeld, West Germany).

*Motortechnische Zeitschrift*, vol. 25, Sept. 1964, p. 1-3. In German.

Discussion of Cr and Al surface diffusion into low-carbon unalloyed steels as a means of improving corrosion and scale resistance. The technique uses volatile Cr and Al halides or atomized metallic Cr and Al; it is described as an effective way of eliminating crack formation, reducing thermoshock sensibility, and obtaining scale-resistant products without affecting tensile and creep strength. Results are tabulated. The method was developed in Germany during World War II to substitute unalloyed for scarce alloyed steels. V. Z.

**A65-27690 #**

**VANISHING SLIP OF MECHANICAL SYSTEMS WITH DRY FRICTION [ISCHEZAIUSHCHIE SKOL' ZHENIA MEKHANICHESKIKH SISTEM S SUKHM TRENIEM].**

G. K. Pozharitskii.

*Prikladnaia Matematika i Mekhanika*, vol. 29, May-June 1965, p. 558-563. In Russian.

Comparative analysis of motions with energy dissipation due to sliding of the frictional surfaces and of motions without friction, in which energy can be conserved. For general systems with friction, sufficient conditions are derived under which an initial motion

with sliding (at low energy influx to the system) will change into a motion without sliding. It is shown that for a sufficiently small sliding rate, the transfer process can be made arbitrarily small. V. P.

**A65-27984 #**

**ON HYDRODYNAMIC LUBRICATION WITH SPECIAL REFERENCE TO SUB-CAVITY PRESSURES AND NUMBER OF STREAMERS IN CAVITATION REGIONS.**

Leif Floberg (Lund Institute of Technology, Mechanical Engineering Dept., Lund, Sweden).

*Acta Polytechnica Scandinavica, Mechanical Engineering Series*, no. 19, 1965. 35 p. 18 refs.

Research sponsored by the Swedish Technical Research Council.

Study of hydrodynamic lubrication of two lightly loaded rotating circular cylinders. Special reference is made to subcavity pressures and the number of oil streamers in cavitation regions; it is theoretically and experimentally shown how the subcavity pressure influences the number of streamers and other bearing quantities. The agreement between theory and tests is good. It is indicated that influence of surface tension can be neglected even at extremely light loads. Pressure distributions, load capacities, and oil flows are calculated, and tests are conducted for pressure distributions, meniscus locations, and load capacities. Included photographs show the test rig and various cavitation boundaries. B. B.

**A65-28341 #**

**THE INTERACTION OF METALLIC NIOBIUM WITH CARBON MONOXIDE [VZAIMODEISTVIE METALLICHESKOGO NIOBIA S OKIS'U UGLERODA].**

G. P. Shveikin and V. A. Pereliev.

*Akademiia Nauk SSSR, Izvestiia, Metallurgy*, May-June 1965, p. 164-169. 8 refs. In Russian.

Investigation of the interaction of carbon monoxide with powdered and compact niobium. In both cases the formation of an oxycarbide phase on the surface of the metal is noted. When tested for chemical strength in a 40% solution of hydrofluoric acid at room temperature, it was found that a specimen of metallic niobium was more subject to the action of the acid than a similar specimen with an oxycarbide coating. A. B. K.

**A65-28600 #**

**OPERATING EXPERIENCE WITH AN OIL-LUBRICATED HIGH-SPEED POTASSIUM TURBINE BEARING.**

Hermann Ernst (General Electric Co., Space Power and Propulsion Section, Cincinnati, Ohio).

*American Society of Mechanical Engineers, Lubrication Symposium*, New York, N.Y., June 6-9, 1965. Paper 65-LUBS-10. 14 p. 16 refs.

Members, \$0.50; nonmembers, \$1.00.

Contract No. NAS5-1143.

Summary of experience gained during analysis, design, and testing of a modern, high-speed, oil-lubricated tilting-pad bearing. The two-stage test turbine operates in saturated potassium vapor with an inlet temperature of 1600°F and is of overhang design. Oil lubrication was chosen because it was considered to be more reliable than liquid-metal lubrication. The tilting-pad bearing was selected because of its good record of suppressing fractional frequency whirl. Applicable data were analyzed and are discussed. Throughout testing, the bearing design demonstrated ruggedness at high speeds, up to 23,000 rpm. F. R. L.

**A65-28628**

**DETERMINATION OF ANNEALING BRITTLINESS BY CORROSION TESTS UNDER TENSION IN THE PRESENCE OF HYDROGEN [MISE EN EVIDENCE DE LA FRAGILITE DE REVENU PAR DES ESSAIS DE CORROSION SOUS TENSION EN PRESENCE D'HYDROGENE].**

Ubirajara Quaranta Cabral, André Hache, and André Constant (Institut de Recherches de la Sidérurgie, Saint-Germain-en-Laye, Seine-et-Oise, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 260, no. 26, June 28, 1965, p. 6887-6890. 6 refs. In French.

Description of an experimental method for determining the degree of brittleness of annealed steels using corrosion tests under

tension in the presence of hydrogen. Annealing brittleness is shown by several tempered steels which had been annealed at temperatures in the 400-550°C range for relatively long periods of time. Such brittleness is not detectable by conventional methods and requires detailed micrographic examination. It is shown that there is a correlation between the existence of such brittleness and the rate of corrosion of steel samples under tension in the presence of  $H_2$ . It is also shown that the same technique is capable of detecting the degree of resistance to cracking. A decinormal  $H_2SO_4$  solution is used as the corrosive agent; tensile strength tests were below the elastic limit.

D. P. F.

**A65-28635 =****HYDROMAGNETIC SQUEEZE FILMS BETWEEN TWO CONDUCTING SURFACES.**

J. B. Shukla (Institute of Higher Technology, Dept. of Mathematics, Kanpur, India) and R. Prasad (U.S.S.D. College, Dept. of Mathematics, Kanpur, India).

American Society of Mechanical Engineers, Lubrication Symposium, New York, N.Y., June 6-9, 1965, Paper 65 - LubS-6, 5 p. 1 refs.

Members, \$0.50; nonmembers, \$1.00.

Analytical investigation of the hydromagnetic theory for squeeze films between two conducting surfaces. It is shown that increase in load capacity, pressure, and time of approach are possible by increasing either the strength of the magnetic field, or conductivities of the surfaces, or both.

(Author) D. P. F.

**A65-28637 =****DESIGN AND MANUFACTURING TECHNIQUES TO PREVENT STRESS CORROSION.**

L. K. Crockett (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.).

American Society of Mechanical Engineers, Design Engineering Conference and Show, New York, N.Y., May 17-20, 1965, Paper 65 - MD-45, 7 p.

Members, \$0.50; nonmembers, \$1.00.

Discussion of stress-corrosion cracking which results from a combination of three factors: (1) material susceptibility, (2) sustained tensile surface stress, and (3) mild corrosive environment. An example of material selection criteria for several large longerons is given where stress corrosion was a primary consideration. Examples of service failures are presented.

F. R. L.

**A65-28639****RELATING BEARING SELECTION TO TOTAL PRODUCT PERFORMANCE.**

Carl H. Keller, Jr. (United Aircraft Corp., Sikorsky Aircraft Div., Stratford, Conn.).

American Society of Mechanical Engineers, Design Engineering Conference and Show, New York, N.Y., May 17-20, 1965, Paper 65 - MD-51, 7 p. 7 refs.

Members, \$0.50; nonmembers, \$1.00.

Evaluation of the many factors which influence bearing selection. Bearing selection without due consideration to all the design parameters may jeopardize reliable product performance. The achievement of successful bearing performance together with confidence in predicting life expectancy is related to a thorough understanding of the design requirements, and a complete evaluation of the operational characteristics of the bearing.

F. R. L.

**A65-28653****METHODS OF THE STUDY OF METAL CORROSION [METODY ISSLEDOVANIYA KORROZII METALLOV].**

V. V. Romanov.

Moscow, Izdatel'stvo Metallurgiya, 1965. 280 p. In Russian.

This book, compiled from both Soviet and foreign sources, is an up-to-date, compact account of the basic methods of metal-corrosion studies, intended to fill the gap in Soviet literature on the subject which has become apparent since the last book of the kind was published nearly 20 years ago. Following a brief description of qualitative corrosion-testing techniques, such as visual observations and macroscopic and microscopic examinations, quantitative methods of corrosion measurement are treated in more detail. These include: loss of weight after the removal of corrosion products

generated by various reagents; the gain in weight when the corrosion product is firmly attached; the amount of hydrogen developed (as in the cathode process); the amount of oxygen absorbed; the time required to form the first corrosion center; the changes in sample thickness and corrosion penetration depth; the change in mechanical behavior under tensile stresses; the change in electrical conduc-

**A65-29304 =****HEAT EXCHANGE, FRICTION, AND MASS EXCHANGE IN A LAMINAR MULTICOMPONENT BOUNDARY LAYER DURING INJECTION OF EXTRANEIOUS GASES [TEPLOOBMEN, TRENIIE I MASSOOBMEN V LAMINARNOM POGORACHIVANOM POGRANICHNOM SLOE PRI VDUVE INORODNYKH GAZOV].**

N. A. Anfimov and V. V. Al'tov.

Teplofizika Vysokikh Temperatur, vol. 3, May-June 1965, p. 409-420, 18 refs. In Russian.

Derivation of approximate formulas for calculating the effect of the injection of individual gases on heat exchange. It is shown that with the aid of data on the effect of the injection of individual gases on heat exchange and friction the corresponding effect for a mixture of gases can be calculated. An approximate expression is derived for the law of mass exchange in a laminar multicomponent boundary layer. The effect of diffusion separation of dissociated air during the injection of extraneous gases is investigated.

A. B. K.

**A65-29311 #****INVESTIGATION OF THE CORROSION OF METALS IN THE PRESENCE OF HEAT TRANSFER [ISSLEDOVANIYE KORROZII METALLOV V USLOVIAKH TEPLOPEREDACHI].**

P. I. Zarubin, L. A. Poluboiartseva, and V. M. Novakovskii (Ural'skii Nauchno-Issledovatel'skii Khimicheskii Institut, Sverdlovsk; Nauchno-Issledovatel'skii Fiziko-Khimicheskii Institut, Moscow, USSR).

Zashchita Metallov, vol. 1, May-June 1965, p. 297-303, 14 refs. In Russian.

Application of rotating disk electrodes to the simulation of diffusive corrosion processes taking place in circular tubes through which flows an aggressive fluid. The technique is shown to provide satisfactory results not only under conditions of thermal equilibrium but also when the fluid is heated (or cooled) through the tube walls. The experiments indicate that if the temperatures of the wall and of the fluid are adequately modeled, the disk velocity equivalent to a given value of linear flow rate can be calculated with sufficient accuracy on the basis of an equivalence equation derived for systems in thermal equilibrium. It is shown that in the presence of heat transfer the effect of the flow rate of the fluid on the rate of diffusive corrosion differs substantially from the effect when thermal equilibrium prevails.

V. P.

**A65-29501 =****ENGINE RATING SYSTEM FOR ASSESSING THE PERFORMANCE OF SYNTHETIC AVIATION TURBINE LUBRICANTS.**

R. F. Overhoff (Esso Research and Engineering Co., Linden, N.J.) and J. P. Perry (Imperial Oil, Ltd., Toronto, Canada).

Esso Air World, vol. 17, May-June 1965, p. 147-155.

Development of a simple rating system for assessing the performance of synthetic lubricants in aircraft gas turbines. Four basic criteria were selected to develop a simplified numerical demerit system for rating aircraft gas turbines. These were (1) to define deposit demerit scales, (2) to establish methods for assigning deposit demerits to the critical parts in different engine models, (3) to confine the mechanical performance to a descriptive assessment, and (4) to develop a simplified photographic technique for illustrating deposits or mechanical conditions. Demerit factors based on types of deposit, thickness of deposit, and color of deposit are tabulated. An application of the rating system is shown in two tables of the rating report on a Pratt and Whitney JT3-D engine.

M. F.

**A65-29781 #****ON THE PREDICTION OF THE WEAR AND DETERIORATION IN PRECISION LAPPING [ZUR VORAUSBESTIMMUNG DES ABSCHLIFFES UND DER ABNUTZUNG BEIM PRÄZISIONSLAPPEN].**

## A65-29870

Edgar Fischer (Dresden, Technische Universität, Institut für elektrischen und mechanischen Feingerätebau, Dresden, East Germany).  
Wissenschaftliche Zeitschrift, vol. 14, no. 1, 1965, p. 177-181. 5 refs. In German.

Theory concerning the lapping motion of the component particles of a tool such as a file and the work piece which makes it possible to predict the expected deterioration of the tool and the wearing down of the work piece. The starting point of the theory is a straight lap line and a straight lapping motion. The generalization to include any lapping motion is also presented. It is shown how the efficiency of a lapping motion can be evaluated, and it is pointed out that the approach described is suitable for optimizing the tooling process.

M. L.

## A65-29870

THE DIFFUSION OF CARBON INTO TUNGSTEN AND MOLYBDENUM AT LOW CARBON CONCENTRATIONS.

L. N. Aleksandrov and V. Ia. Shchelkonogov (Mordovskii Gosudarstvennyi Universitet, Saransk, USSR).  
 (Poroshkovaia Metallurgii, July-Aug. 1964, p. 28-32.)  
Soviet Powder Metallurgy and Metal Ceramics, July-Aug. 1964, p. 288-291. 9 refs. Translation.

Investigation of the conditions under which tungsten and molybdenum become contaminated with carbon at high temperature, by means of the use of  $C_{14}$ . Results are presented for grade VRN tungsten specimens 0.8 mm in diameter and grade Mch molybdenum specimens 0.4 mm in diameter. The specimens are coated with a 1 to 20 mixture of graphite lubricant and  $C^{14}$  mixture. It is known that for tungsten,  $W_2C$  is formed when the carbon is present in excess of 0.05 wt %, and for molybdenum,  $Mo_2C$  is formed when carbon concentration is 0.15 wt % or greater. Annealing of the prepared specimens is by conduction at 1100 to 1450°C in hydrogen to prevent oxidation. Graphs showing the carbon diffusion rates for tungsten and molybdenum are included, together with equations for the concentration distribution of the diffusing element. It is concluded that the principal diffusion constants of carbon - the pre-exponential factor  $D_0$  and the energy of activation of the process,  $Q$  - are determined with the aid of  $C_{14}$ . It is found that as a result of annealing for 3.5 hr in the specified temperature range carbon penetrates into tungsten and molybdenum to depths of 5 and 40  $\mu$ , respectively.

M. L.

## A65-30030

A METHOD OF TESTING DRY FILM LUBRICANTS IN AN ULTRA-HIGH VACUUM.

Robert N. Hager, Jr. (General Dynamics Corp., General Dynamics Convair, San Diego, Calif.).  
 IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, 11TH, CHICAGO, ILL., APRIL 21-23, 1965, PROCEEDINGS. [A65-29982 19-11]  
 Mount Prospect, Ill., Institute of Environmental Sciences, 1965, p. 365-368.

Description of a unique method of studying dry film lubricants exposed to an ultra-high-vacuum environment. An all-metal sealed, stainless steel chamber, 12 in.-diam by 18-in. long houses the test fixture, which is contained on one of the chamber end plates. Pumping is accomplished by cryosorption and getter-ion pumps. The ion pump and chamber can be surrounded by a folding oven and baked to 500°F. A residual gas analyzer, mounted on the chamber, continually records chamber partial pressures from mass 2 to 150. The test fixture contains a standard Falex journal mounted on the end of a torsion shaft, rotating between standard Falex vee blocks at 190 rpm. A magnetic coupled feed-through is used to transmit rotary motion into the chamber. The journal and vee blocks are coated with the lubricant under study. A linear motion feed-through is used to vary the load on the vee blocks. Friction in the test specimen is transmitted as a torque through the torsion shaft. The resulting twist of the shaft is monitored by two magnetic pickups located under gears attached to both ends of the torsion shaft. The electrical pulses from the two pickups are fed into an electronic circuit, which produces a dc output proportional to the relative phase of displacement of the two signals. This output is therefore proportional to both the angle of twist in the torsion shaft, and the coefficient of friction at the test specimen with a constant load.

(Author) B. B.

## A65-30154 #

ON THE IMPROVEMENT OF THE TURBULENT LUBRICATION THEORY, BY USING THE MIXING-LENGTH HYPOTHESIS.

V. N. Constantinescu (Rumanian Academy, Institute of Applied Mechanics, Bucharest, Rumania).

Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée, vol. 10, no. 2, 1965, p. 421-437. 18 refs.

Critical examination of the turbulent lubrication theory. It is shown that the mixing-length hypothesis may be considered as a useful method in developing a coherent theory of turbulent lubrication. Some improved relations for the calculation of the parameters  $k_x$  and  $k_z$  are given, as well as some considerations on the determination of the constant which determines the mixing-length variation and on the use of the mixing-length hypothesis for nonplanar flows.

(Author) M. F.

## A65-30155 #

ON THE CALCULUS OF LUBRICATION SYSTEMS WITH FLUID LUBRICANTS.

Al. Nica (Rumanian Academy, Institute of Applied Mechanics, Bucharest, Rumania).

Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée, vol. 10, no. 2, 1965, p. 439-450. 5 refs.

Method permitting the determination of the head losses in pipes of fluid lubrication systems. Some practical simple cases are considered (pipes in series and in parallel) and relations between their characteristic parameters are established. A general method for the computation of flow rates in pipe networks is presented. Numerical examples are included.

(Author) M. F.

## A65-30156 #

FRICITION AND WEAR ASPECTS IN THE MOLYBDENUM DISULFIDE LUBRICATION.

Olga Biță and I. Dincă (Rumanian Academy, Institute of Applied Mechanics, Bucharest, Rumania).

Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée, vol. 10, no. 2, 1965, p. 451-462. 10 refs.

Observations and experimental results concerning the influence of the purity and grain size of various qualities of natural and synthetic molybdenum disulfide on the friction and wear of metal surfaces, tested under conditions of variable operation parameters. The efficiency of molybdenum disulfide ( $MoS_2$ ), used as lubricant, is found to be strongly influenced by the purity and the homogeneity of the grain size.

(Author) M. F.

## A65-30199 #

MECHANICAL AND CHEMICAL CONTRIBUTIONS TO THE EROSION RATES OF CARBON CHOKES IN ROCKET MOTOR NOZZLES.

V. R. Gowariker (Imperial Metal Industries /Kynoch/, Ltd., Ballistics and Mathematical Services Dept., Summerfield Research Station, Kidderminster, England).

American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-351. 12 p. 5 refs.

Members, \$0.50; nonmembers, \$1.00.

Investigation of throat erosion in a rocket nozzle over a wide range of graphite grades, pressures, and propellants. The erosion is assumed to be attributable to both surface chemical reactions and mechanical removal. The degree of effectiveness of each of these factors depends on the composition of the reacting products in the combustion gases, the temperature, the pressure, and the quality of the carbon. A simplified diffusion equation is solved for the turbulent boundary layer close to the carbon surface, and a suitable expression for the mass-transfer coefficient that considers the geometry of the convergent portion of the nozzle is employed to evaluate the chemical contribution. For the mechanical effect, a simple logarithmic function which depends on the porosity of the carbon choke and the characteristic velocity of the propellant gases is determined using dimensional analysis and experimental data.

S. H. B.

**A65-30288 \***

GRAPH-ANALYTICAL METHOD OF TAKING INTO ACCOUNT THE EFFECT OF THE FORCES OF DRY FRICTION IN THE BEARING ON THE OPERATION OF A GYROSCOPE [GRAFOANALITICHESKII SPOSOB UCHETA STEPENI VLIYANIYA SIL SUKHOGO TRENIYA V OPORAKH NA RABOTU GIROSKOPA].

M. N. Katkhanov and V. P. Demidenko (Voennaia Artilleriiskaia Akademiia, Moscow, USSR).

*Priborostroenie*, vol. 8, no. 3, 1965, p. 104-108. In Russian.

Description of a graph-analytical method of determining the effectiveness of the action of the forces of dry friction in the bearing of a gyroscope suspension under various conditions of operation. The principle of construction and utilization of a nomogram for determining the coefficient of effectiveness of the action of the corresponding friction moment is illustrated by a specific example.

A. B. K.

**A65-30467 \***

ALUMINUM.

B. Wyma (Aluminum Company of America, Pittsburgh, Pa.).

*I & EC - Industrial and Engineering Chemistry*, vol. 57, Aug. 1965, p. 85-88, 40 refs.

Review of progress in aluminum technology and applications. Alloys such as X5015 and Anoclad Al3 have been developed with improved corrosion and abrasion resistance. Increased productivity of aluminum strip has resulted from the use of a continuous casting line that produces sound sheet in a wide range of alloys including heat-treatable alloys. Electroforming of aluminum optical components has produced nonmagnetic solar energy concentrators for space applications. Several other applications of aluminum in space technology are described.

S. H. B.

**A65-30552**

THE ANODIC DISSOLUTION OF GERMANIUM.

B. Lovreček and K. Moslavac (Zagreb, University, Faculty of Technology, Institute of Electrochemistry and Electrochemical Technology, Zagreb, Yugoslavia).

(International Committee of Electro-Chemical Thermodynamics and Kinetics, Meeting, 15th, London, England, Sept. 21-26, 1964, Paper.)

*Electrochimica Acta*, vol. 10, June 1965, p. 627-635. 9 refs.

Investigation of anodic dissolution of n-type germanium. Experimental conditions were achieved which made possible the construction of a potential/current ( $e_1/i^*$ ) diagram, in a broad current density range, which satisfies the condition  $p_1 = p_0$ , - i.e., the concentration of holes on the boundary of the space charge region ( $p_1$ ) equals the equilibrium concentration of holes in the bulk of the semiconductor ( $p_0$ ). Potential/current curves constructed in such a way are compared with similar earlier attempts. Taking these results, by an analogy with surface photoeffect, the saturation current of holes ( $i_{p, sat}$ ) in anodic polarization is calculated. Further, it is possible to separate the parts of the overall overpotential which correspond to the transport phenomenon of holes ( $\eta_T, p$ ) and injection by chemical reaction ( $\eta_{L, i}$ ), respectively. These values calculated from experimental results are compared with those to be expected theoretically.

(Author) F. R. L.

**A65-30599**

LUBRICATION AND WEAR.

*Lubrication*, vol. 51, no. 6, 1965, p. 61-80.

Study of the lubrication and wear of steel bearing surfaces and mineral-oil lubricant systems. The classical and elastohydrodynamic situations are compared. The existence of micro-elastohydrodynamic lubrication has not been explicitly demonstrated. Rather, it has been inferred from experimental data showing trends in the intuitively expected directions. Observations concerning the onset of wear without a change in friction point up the fact that, in the absence of gross scoring or galling, friction is almost entirely due to shearing of the lubricant film. These are various means by which wear may occur: (1) corrosion, (2) fatigue, (3) cutting or plowing, (4) adhesion or welding. The physical factors influencing wear are considered. Recent investigations of antiwear and extreme-pressure films have only demonstrated the need for discarding some established ideas, but without providing much positive evidence to support alternate concepts. It is believed that much more work is required, particularly in the fields of solid-state and surface chemistry and physics, to bring this subject out of the realm of speculation and empiricism.

M. F.

**A65-30744 \***

STUDY OF STRUCTURAL ALLOYS BASED ON Al-Zn-Mg SYSTEM. IV - CORROSION CHARACTERISTICS OF Al-Zn-Mg ALLOYS.

Ikuo Tani and Yutaka Ishikawa (Furukawa Aluminium Co., Ltd., Nikko Works, Nikko, Japan).

*Light Metals (Tokyo)*, vol. 15, May 1965, p. 4-17. 18 refs. In Japanese.

Investigation of corrosion tests on Al-Zn-Mg alloys under various conditions. The interdependence between structures and corrosion conditions must be considered when studying the corrosion characteristics of such alloys. It is found that these alloys have the same corrosion resistance as other corrosion-resistant Al alloys as regards reduction in tensile strength; however, Al-Zn-Mg alloys seem to be more subject to pitting corrosion than other Al alloys. Extrusion textures in naturally aged alloys based on the Al-Zn-Mg system, which contain not less than 0.2% Cr or 0.6% (Mn + Cr), show extrafoliation on exposure to an NaCl solution containing not less than 1% H<sub>2</sub>O<sub>2</sub> or HCl solution. Al-Zn-Mg alloys containing not more than 5% Zn are not sensitive to stress-corrosion cracking and are therefore safe for practical purposes.

(Author) D. P. F.

**A65-30815**

A THIN FILM LUBRICANT FOR CONNECTOR CONTACTS.

Jack Spengel, Elmer Godwin (U. S. Army, Electronics Command, Electronics Laboratories, Fort Monmouth, N. J.), and Gunther Steinberg (Stanford Research Institute, Menlo Park, Calif.).

(Institute of Electrical and Electronics Engineers, The 1965 Electronic Components Conference, Washington, D. C., May 5-7, 1965, Paper.)

*IEEE Transactions on Parts, Materials and Packaging*, vol. PMP-1, June 1965, p. s-1 to s-9. 11 refs.

Description of a thin film-lubricant developed for gold-plated contacts. This film is octadecylamine hydrochloride (ODA-HCL), and it exhibits excellent adherence to gold surfaces. The friction between solid gold surfaces and gold-plated surfaces was reduced by a factor of approximately 4 to 1. The lubricating properties of this film have been adequately demonstrated under loads ranging from 20 to 300 g while providing metal-to-metal electrical contact. The stability of this film has been demonstrated in exposure tests performed in the laboratory, as well as direct exposure to industrial, marine, and smog atmospheres in the US. In all instances, the thin film maintained its lubricating properties and its low electrical resistance characteristics. The adherence of the film to the gold surface is believed to involve only physical adsorption, primarily by van der Waals forces; however, this phenomenon is still being studied. An interim batch method of coating contacts which was developed indicates the feasibility of a production technique for applying reliable coatings to contacts. Octadecylaminehydrochloride film was found to be superior to other types of lubricants tried on gold-plated surfaces, and it offers a potential of considerable improvement in gold-plated connector contacts in a wide variety of applications.

(Author) R. A. F.

**A65-31094**

ELECTRICAL SLIDING CONTACTS FOR APPLICATION IN SPACE ENVIRONMENTS.

L. E. Moberly and J. L. Johnson (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

(1965 Aerospace Technical Conference and Exhibit, Houston, Tex., June 21-24, 1965, Paper.)

*IEEE Transactions on Aerospace*, vol. AS-3, June 1965, Supplement, p. 252-257. 9 refs.

Determination that performance characteristics of electrical contacts lubricated with niobium diselenide are superior to similar materials lubricated with molybdenum disulfide while transferring power to a slow-speed silver slip ring for a period of 1000 hr. Lower and more stable contact voltage was the main improvement shown while operating in a vacuum chamber near  $2.0 \times 10^{-8}$  torr.

(Author) B. B.

**A65-31144**

ROTATING MACHINES FOR EXTREME ENVIRONMENTS.

D. Irani and C. S. Smith (Garrett Corp., AiResearch Manufacturing Co., Los Angeles, Calif.).



(1965 Aerospace Technical Conference and Exhibit, Houston, Tex., June 21-24, 1965, Paper.)

IEEE Transactions on Aerospace, vol. AS-3, June 1965, Supplement, p. 620-627. 25 refs.

Discussion of materials selection and design considerations of rotating machines subjected to difficult environmental conditions. Problems affecting the design of a rotating machine, such as conductor and magnetic materials, insulation systems, bearings, and performance, are described. Advantages and disadvantages of various materials for various functions are discussed and summarized in tables. Environmental factors considered include heat, radiation, vacuum, and magnetic fields.

(Author) R. A. F.

#### A65-31216 \*

STRUCTURE OF PSEUDOGELS OBTAINED BY THICKENING HYDRO-CARBON OILS WITH SOAPS OF SATURATED CARBOXYLIC ACIDS [STRUKTURA PSEVDOGELI POLUCHAEMYKH ZAGUSHCHENIEM UGLEVDORODNYKH MASEL Ca- I Li-MYAMI PREDEL'NYKH KARBONOVYKH KISLOT].

V. V. Sinitsyn, Iu. L. Ishchuk, and V. A. Prokopchuk.

Akademiia Nauk SSSR, Doklady, vol. 163, July 11, 1965, p. 426-429. 8 refs. In Russian.

Systematic study of the relation between the chain length in a homologous series of saturated aliphatic acids and the structure of the pseudogels obtained by thickening them with their Li and Ca soaps. The structure of lubricants based on soaps of mixtures of these acids is considered. The effect of mechanical deformation on the structure of the pseudogels is investigated, and the relation between the structure and the rheological properties of Ca and Li lubricants is determined.

A. B. K.

#### A65-31372

INSIDE AND OUT.

Flight International, vol. 88, Aug. 12, 1965, p. 255-258.

General discussion of aircraft paints, finishes, and anticorrosion processes. Aircraft life is set at a figure ranging from 10 to 15 yr; corrosion is generated from within by such compositions as hydraulic fluid and from water condensation effects caused by temperature and pressure changes. Rain, salt water, and industrial effluents tend to corrode the airframe from without. Joints are particularly liable to corrosion; there are three basic methods to improve resistance to corrosion - cathodic protection, waterproofing of the joint by the application of a sealant, and the painting of all surfaces before assembly. Anodizing is an excellent protective treatment for aluminum and ensures a good bond for subsequent painting. Chromate inhibitors have been found very useful in checking corrosion when incorporated with aircraft paints.

D. P. F.

#### A65-31529

STRUCTURAL CHANGES IN GRAPHITIZED MATERIALS DURING WEAR.

L. P. Grigorenko, L. A. Plutalova, and B. M. Rovinskii (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Mashinovedeniia, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 160, Feb. 1, 1965, p. 807-810. Soviet Physics - Doklady, vol. 10, Aug. 1965, p. 154-156. 5 refs. Translation.

Analysis of the structural changes occurring during the friction of AG-1500 antifriction graphite material on M-3 copper, 1Kh18N9 steel, and chromium at  $10^{-5}$  mm Hg. A comparison is made of the crystal sizes and the integral line intensities of the initial material and the wear products. The possibility that grinding and shear cause a conversion from the hexagonal to a monoclinic form of graphite is examined by calculating the intensity ratios for certain coincident lines of the two forms.

A. B. K.

#### A65-31530

ANTIFRICTION PROPERTIES OF SOLIDS AT HIGH TEMPERATURES UNDER VACUUM AND IN GASES.

A. P. Semenov and V. V. Pozdniakov (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Mashinovedeniia, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 160, Feb. 1, 1965, p. 811-814.) Soviet Physics - Doklady, vol. 10, Aug. 1965, p. 157-159. Translation.

[For abstract see Accession no. A65-23565 13-17]

#### A65-31684

MICROSTRUCTURAL ASPECTS OF STRESS-CORROSION FAILURE. P. R. Swann and J. D. Embury (United States Steel Corp., Research Center, Edgar C. Bain Laboratory for Fundamental Research, Monroeville, Pa.).

IN: HIGH-STRENGTH MATERIALS; BERKELEY INTERNATIONAL MATERIALS CONFERENCE, 2ND, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF., JUNE 15-18, 1964, PROCEEDINGS. [A65-31680 20-17]

Conference supported by the Atomic Energy Commission.

Edited by V. F. Zackay.

New York, John Wiley and Sons, Inc., 1965, p. 327-355; Comments, M. R. Louthan, Jr. (Du Pont de Nemours and Co., Inc., Savannah River Laboratory, Aiken, S.C.), p. 355-359; Discussion, p. 359-362. 41 refs.

AEC Contract No. AT(07-2)-1.

Determination of the influence of dislocations on the nucleation and propagation of stress-corrosion cracks. Electron-microscope studies of many alloys susceptible to transgranular stress-corrosion cracking show that tunnel corrosion is the characteristic mode of attack by environments which cause cracking, and the rates of crack propagation compare well with earlier data. The observations are considered to support the theory that cracking propagates by the ductile-rupture of a slot weakened by many tubular corrosion pits lying in the crack plane. The most important properties of the stress-corrosion environment in the nucleation of transgranular stress-corrosion cracks are believed to be that a surface film must form over most of the alloy surface; that the environment must be able to support tunnel corrosion; that the mechanical properties and thickness of this film must be such that it can be ruptured by slip; and that the repair rate of the surface film must be slow enough and the creep rate of the specimen fast enough, for the environmental conditions necessary for tunnel corrosion to be established at the exposed slip step.

F. R. L.

#### A65-31715

AN ELECTRON MICROSCOPE STUDY OF ROLLING CONTACT FATIGUE.

George S. Reichenbach and Walter D. Syniuta (Massachusetts Institute of Technology, Mechanical Engineering Dept., Cambridge, Mass.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-29.)

ASLE Transactions, vol. 8, July 1965, p. 217-223. 8 refs.

Research supported by the United Aircraft Corp.

Study of the progressive changes in the surface topography of the running track in a rolling contact fatigue tester, using replica techniques and the electron microscope. Early in the life of a specimen, micron-size cracks are found to appear in the stressed surface. With further running, more cracks are seen to appear. However, those existing already are found not to grow to any extent except in isolated cases. When the lubricant is changed, the time to form the first few cracks and the rate of formation of additional cracks are found to correlate well with the fatigue performance. Etching of the ball tracks shows that the surface cracks observed are almost always located at the chrome carbide to martensite interface. It is postulated that corrosion fatigue may contribute to the differences between the fatigue performance of lubricants as much as or more so than elastohydrodynamic effects.

(Author) M. L.

#### A65-31716

THE ISOTHERMAL LUBRICATION OF CYLINDERS.

D. Dowson and A. V. Whitaker (Leeds University, Dept. of Mechanical Engineering, Leeds, England).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64 LC-22.)

ASLE Transactions, vol. 8, July 1965, p. 224-233; Discussion,

Y. P. Chiu and T. E. Tallian (SKF Industries, Inc., King of Prussia, Pa.), p. 233, 234; Authors' Closure, p. 234. 14 refs.

Research supported by the Department of Scientific and Industrial Research.

Consideration of the hydrodynamic problem of cylinder lubrication. Rigid solids lubricated by a constant-property fluid, rigid solids lubricated by a variable-property fluid, and elastic solids

lubricated by a variable-property fluid are considered. The cylinder is selected for analysis since many real contacts in machinery can be represented. It is found that for light loads, the cylinders retain their unloaded geometry, but, when the contact forces are large, significant elastic deformation may occur. Computing methods appropriate to the "rigid" and "elastic" situations are summarized. The valid application range of the "rigid" and "elastic" film thickness relationships is discussed, and an intermediate range is defined. A chart to enable a particular problem to be located in the "rigid," "intermediate," or "elastic" zone is presented. M. L.

#### A65-31717

##### DISTRIBUTION OF HYDRODYNAMIC PRESSURE ON COUNTER-FORMEL LINE CONTACTS.

G. Niemann and F. Gartner (München, Technische Hochschule, Forschungsstelle für Zahnräder und Getriebe, Munich, West Germany).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64-LC-12.)

ASLE Transactions, vol. 8, July 1965, p. 235-244; Discussion, D. Dowson (Leeds, University, Leeds, England), H. Christensen (Norway, Technical University, Engineering Research Foundation, Trondheim, Norway), and E. A. Ryder, p. 244-248; Authors' Closure, p. 248, 249. 18 refs.

Results of measurements of the pressure distribution of counterformel cylinders. Within the small zone of contact, pressure curves are obtained which are correct both qualitatively and quantitatively. Integration of the pressure gives the hydrodynamic borne load. This load is found to agree with the applied load in the region of fluid friction. Under conditions of mixed friction, a steady decrease in the developed pressures is observed. There is no sudden breakdown of pressure. The following effects are investigated: speed, load, viscosity, curvature, roughness, and lubricant. The highest measured pressure is 60,000 psi. This pressure exceeds the maximum of the hertzian distribution.

(Author) M. I.

#### A65-31719

##### TEMPERATURE - THE KEY TO LUBRICANT CAPACITY.

E. F. Leach and B. W. Kelley (Caterpillar Tractor Co., Peoria, Ill.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64-LC-13.)

ASLE Transactions, vol. 8, July 1965, p. 271-279; Discussion, p. 280-284; Authors' Closure, p. 284, 285. 20 refs.

Results of an investigation showing that the failure of a non-reactive mineral oil can be predicted by Blok's formula for determining the maximum temperature between two bodies in rolling and sliding contact. The evaluation of many lubricants on a geared roller test machine is discussed, and it is shown that the lubricant failure for any particular lubricant-material combination occurs at a constant, critical contact temperature, film thickness, and viscosity grade. The coefficient of friction can be predicted by a parameter involving the unit load, inlet viscosity, sum velocity, and sliding velocity. The load capacity of a lubricant is shown to vary inversely with specimen temperature for a constant set of test conditions. Electrical-resistance measurements across the contact zone are shown to aid in identifying the lubricant failure point and in revealing the action of two deposit-forming additives.

(Author) M. L.

#### A65-31720

##### TURBULENT AND INERTIA FLOW IN SLIDER BEARINGS.

C. F. Kettleborough (New South Wales, University, Dept. of Mechanical Engineering, Kensington, Australia).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Washington, D.C., Oct. 13-16, 1964, Paper 64-LC-16.)

ASLE Transactions, vol. 8, July 1965, p. 286-295. 8 refs.

Presentation of a computer solution developed in terms of matrix algebra, in which the equations of a slider bearing are analyzed which include the inertia, turbulent, and viscous terms. It is found that for small values of turbulence the results indicate that the dominant term after the viscous term is the inertia term, and that the inclusion of the Reynolds turbulent stress term actually

causes a slight decrease in load capacity. A numerical example is considered, and it is concluded that the inertia effects alone can be considerable and cannot be neglected. The role of turbulence effects is found to be still undecided.

(Author) M. L.

#### A65-32167

##### THE CORROSION-RESISTANCE OF NICKEL-CHROMIUM COATINGS - SOME ELECTROCHEMICAL AND METALLOGRAPHIC FEATURES.

G. N. Flint (International Nickel Co./Mond/, Ltd., Development and Research Department Laboratory, Birmingham, England) and S. H. Melbourne (Steel Company of Wales, Port Talbot, Wales). IN: AUSTRALIAN CONFERENCE ON ELECTROCHEMISTRY, 1ST, SYDNEY AND HOBART, AUSTRALIA, FEBRUARY 13-20, 1963, PROCEEDINGS. [A65-32164 20-03]

Conference sponsored by the Royal Australian Chemical Institute, the University of New South Wales, and the University of Tasmania. Edited by J. A. Friend and F. Gutmann.

Oxford, Pergamon Press, Ltd., 1965, p. 399-416. 26 refs.

Discussion of improved nickel-chromium coatings in terms of the electrochemical and metallographic features associated with the protection against corrosion provided by such coatings. The major cause of breakdown is shown to be pitting by atmospheric corrosion under conditions of cathodic control. Experiments are noted which provide strong evidence that cathode polarization at the chromium surface is a major factor in controlling the rate of corrosion penetration of nickel-chromium coatings. Some improvements that can be obtained by modifications in undercoat and topcoat are described.

V. P.

#### A65-32310

##### MAGNETO-HYDRODYNAMICALLY LUBRICATED EXTERNALLY PRESSURIZED BEARING WITH VARIABLE FILM THICKNESS.

J. B. Shukla (Indian Institute of Technology, Dept. of Mathematics, Kanpur, India).

Applied Scientific Research, Section B, vol. 11, no. 6, 1965, p. 453-460.

Theoretical study of the use of a conducting lubricant in an externally pressurized bearing with variable film thickness in the presence of an axial magnetic field. The flow and other characteristics are determined, and it is shown that the pressure and load capacity can be increased by increasing the strength of the applied magnetic field at a given flow rate. But at a given feeding pressure, the load capacity and pressure do not depend on the magnetic field. The load capacity of this bearing is greater than that of a bearing having a constant film thickness. It is also pointed out that the frictional drag on the rotor can be minimized by supplying electrical energy to the system.

(Author) B. B.

#### A65-32402

##### BERYLLIUM CORROSION AND HOW TO PREVENT IT.

A. J. Stonehouse and W. W. Beaver (Brush Beryllium Co., Chemistry Dept., Cleveland, Ohio).

(National Association of Corrosion Engineers, Annual Conference, 20th, Chicago, Ill., Mar. 9-13, 1964, Paper.)

Materials Protection, vol. 4, Jan. 1965, p. 24-28. 27 refs.

Review of the corrosion-resistant characteristics of beryllium and a discussion of four types of beryllium corrosion: aqueous, atmospheric, and that due to high-temperature gases and liquid metals. It is shown how corrosion can be minimized on unprotected beryllium. The protection achieved with anodized coatings on beryllium is discussed. Other protective systems considered are metallic paint and enamel systems, electroless nickel coatings, and inhibitors for aqueous applications.

(Author) M. F.

#### A65-32404

##### COMPATIBILITY OF TITANIUM AND NITROGEN TETROXIDE.

R. L. Wallner, B. B. Williams, and A. C. Simmons (North American Aviation, Inc., Downey, Calif.).

(National Association of Corrosion Engineers, Annual Conference, 20th, Chicago, Ill., Mar. 9-12, 1964, Paper.)

Materials Protection, vol. 4, Jan. 1965, p. 55, 56.

Discussion of compatibility tests of nitrogen tetroxide and titanium containing 6% aluminum and 4% vanadium. The testing involved the immersion of samples in nitrogen tetroxide to evaluate the corrosive attack and impact sensitivity tests to determine the effect of a sudden energy release on titanium exposed to nitrogen tetroxide.

(Author) M. F.

**A65-32761**

ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. GENERAL PAPERS. London, Institution of Mechanical Engineers, 1965. 165 p.

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THE THEORETICAL EFFECTS OF ELASTIC DEFORMATION OF THE BEARING LINER ON JOURNAL BEARING PERFORMANCE. G. R. Higginson (Royal Military College of Science, Shrivenham, Wilts., England), p. 1-8.

FOIL BEARINGS - THEIR GENERAL BEHAVIOUR WITH PARTICULAR EMPHASIS ON THE EXTERNALLY PRESSURIZED BEARING. M. Wildmann (Ampex Corp., Redwood City, Calif.), p. 9-16.

## ELASTOHYDRODYNAMIC LUBRICATION AT POINT CONTACTS.

J. F. Archard (Leicester, University, Leicester, England) and E. W. Cowking (English Electric Co., Ltd., Whetstone, Middx., England), p. 17-26. 15 refs. [See A65-32762 21-15]

A NUMERICAL PROCEDURE FOR THE SOLUTION OF THE ELASTOHYDRODYNAMIC PROBLEM OF ROLLING AND SLIDING CONTACTS LUBRICATED BY A NEWTONIAN FLUID. D. Dowson and A. V. Whitaker (Leeds, University, Leeds, England), p. 27-41. 19 refs. [See A65-32763 21-15]

THE THERMODYNAMICS OF A VISCOELASTIC FILM UNDER SHEAR AND COMPRESSION. R. A. Burton (Southwest Research Institute, San Antonio, Tex.), p. 42-47. [See A65-32802 21-12]

TEMPERATURE AT SCUFFING. J. P. O'Donoghue (Joseph Lucas and Co., Ltd., Burnley, Lancs., England) and A. Cameron (London, University, London, England), p. 48-57.

FURTHER EXPERIMENTS ON THE EFFECT OF METALLIC CONTACT ON THE PITTING OF LUBRICATED ROLLING SURFACES. P. H. Dawson (Associated Electrical Industries, Ltd., Manchester, England), p. 58-63.

HYDRODYNAMIC LUBRICATION OF PROXIMATE CYLINDRICAL SURFACES OF LARGE RELATIVE CURVATURE. W. Lauder (Strathclyde, University, Glasgow, Scotland), p. 64-69.

PRESSURE DISTRIBUTIONS IN A HIGHLY LOADED LUBRICATED CONTACT. M. D. Longfield (Leeds, University, Leeds, England), p. 70-75.

THE MEASUREMENT OF OIL-FILM THICKNESS IN ELASTO-HYDRODYNAMIC CONTACTS. A. Dyson, H. Naylor, and A. R. Wilson (Shell Research, Ltd., Chester, England), p. 76-91. 14 refs. [See A65-32764 21-15]

MEASUREMENTS OF PRESSURES IN ROLLING CONTACT. J. W. Kannel (Battelle Memorial Institute, Columbus, Ohio), p. 92-99. 12 refs. [See A65-32765 21-15]

NATURE OF METALLIC CONTACT IN MIXED LUBRICATION. H. Christensen (Norway, Technical University, Trondheim, Norway), p. 100-110. 6 refs. [See A65-32766 21-15]

A CORRELATION BETWEEN THE THEORETICAL AND EXPERIMENTAL RESULTS ON THE ELASTOHYDRODYNAMIC LUBRICATION OF ROLLING AND SLIDING CONTACTS. H. S. Cheng and F. K. Orcutt (Mechanical Technology, Inc., Latham, N.Y.), p. 111-121. 16 refs. [See A65-32767 21-15]

PARTIAL ELASTOHYDRODYNAMIC LUBRICATION IN ROLLING CONTACT. T. E. Tallian, J. I. McCool, and L. B. Sibley (SKF Industries, Inc., King of Prussia, Pa.), p. 122-137. 18 refs. [See A65-32768 21-15]

THE LUBRICATING CONDITION OF A LIP SEAL. F. Hirano (Kyushu University, Fukuoka, Japan) and H. Ishiwata (Nippon Oil Seal Industry Co., Ltd., Tokyo, Japan), p. 138-147. 7 refs. [See A65-32769 21-15]

THE MECHANICS OF ROLLER BEARINGS. P. Garnell and G. R. Higginson (Royal Military College of Science, Shrivenham, Wilts., England), p. 148-156.

ELASTOHYDRODYNAMIC BEHAVIOUR OBSERVED IN GEAR TOOTH ACTION. Darle W. Dudley (Mechanical Technology, Inc., Latham, N.Y.), p. 157-165. 11 refs. [See A65-32770 21-15]

**A65-32762**

ELASTOHYDRODYNAMIC LUBRICATION AT POINT CONTACTS. J. F. Archard (Leicester, University, Dept. of Engineering, Leicester, England) and E. W. Cowking (English Electric Co., Ltd., Whetstone, Middx., England).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. GENERAL PAPERS.

[A65-32761 21-15]

London, Institution of Mechanical Engineers, 1965, p. 17-26. 15 refs.

Comparison of the classical hydrodynamic theory, which leads to the concept of a side-leakage or ellipticity factor  $\Phi$ , which is the proportional reduction in pressure attributable to the existence of side-leakage. In the isoviscous theory of an undeformed point contact  $\Phi$  is a constant equal to  $[1 + (2R_x/3R_y)]^{-1}$  where  $R_x$  and  $R_y$  are the effective radii of curvature parallel to and perpendicular to the direction of motion. This concept is used in the derivation of simple elastohydrodynamic theories for a point contact. The theories agree reasonably well with measurements of the film thickness using the crossed-cylinders machine under conditions in which  $R_x/R_y$  was varied between approximately 0.3 and 12.0. Two semianalytical solutions of the theory of elastohydrodynamic lubrication at point contacts are presented. It is assumed that the shape of the surface is identical with that which occurs under the same load in the absence of a lubricant; the film in the central region is therefore assumed to be parallel. Isobar plots of deduced values of the reduced pressure  $q$  are shown. These solutions and Archard's numerical integration all give expressions for the film thickness approximately of the form  $h \propto (\alpha \eta_0 u)^{3/4} R^{5/12} (\omega^2/E')^{-1/12}$ .

F.R.L.

**A65-32764**

THE MEASUREMENT OF OIL-FILM THICKNESS IN ELASTO-HYDRODYNAMIC CONTACTS.

A. Dyson, H. Naylor, and A. R. Wilson (Shell Research, Ltd., Thornton Research Center, Chester, England).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. GENERAL PAPERS. [A65-32761 21-15]

London, Institution of Mechanical Engineers, 1965, p. 76-91. 14 refs.

Assessment of the validity of elastohydrodynamic lubrication theory by use of the values of oil-film thickness predicted by Dowson and Higginson, which are compared with measurements obtained by experiment in a disk machine lubricated with a wide variety of fluids. It is shown that, over the range 1 to 40  $\mu$ in., theoretical and measured values are in close agreement for most of the fluids examined. Thus, over this range the predicted dependence of film thickness  $h$  on rolling speed  $u$ , viscosity  $\eta_0$ , and pressure coefficient of viscosity  $\alpha$  is confirmed. The experimental results are consistent with the expression  $h \propto (u \eta_0)^{0.65} \alpha^{0.56}$ . The insensitivity of film thickness to load at loads exceeding 400 lb/in. and to sliding at constant rolling speed is also demonstrated. A tentative explanation is offered of the discrepancies between theoretical and measured values that emerge under conditions producing thicker films. Unlike most of the fluids examined, a polymer solution and a polydimethyl silicone fluid formed films significantly thinner than predicted.

F.R.L.

**A65-32767**

A CORRELATION BETWEEN THE THEORETICAL AND EXPERIMENTAL RESULTS ON THE ELASTOHYDRODYNAMIC LUBRICATION OF ROLLING AND SLIDING CONTACTS.

H. S. Cheng and F. K. Orcutt (Mechanical Technology, Inc., Latham, N.Y.).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. GENERAL PAPERS. [A65-32761 21-15]

London, Institution of Mechanical Engineers, 1965, p. 111-121. 16 refs.

Navy-supported research.

Summaries of major experimental data on the pressure, temperature, and film thickness between two circular disks, as well as theoretical solutions of the thermal-elastohydrodynamic lubrication of infinitely long rollers. Correlation is made between theoretical and experimental results. Agreement between the theoretical and experimental film thickness and surface temperatures is found to be fair, but major discrepancies are shown to exist between the measured and predicted pressure distributions. The sharp pressure peak predicted by the theory was not observed in the experimental pressure distributions; however, certain discontinuities in the pressure slope were discovered in the exit region of the pressure profile. Possible reasons for the discrepancy of pressure data are discussed.

In addition, an isothermal elastohydrodynamic solution considering viscoelastic effects of the lubricant is investigated. The behavior of the lubricant is assumed to obey the law of a Maxwellian fluid. Preliminary results show that the viscoelastic effect is extremely important and could completely remove the pressure peak found in the results based on a Newtonian lubricant. F.R.L.

#### A65-32769

##### THE LUBRICATING CONDITION OF A LIP SEAL.

F. Hirano (Kyushu University, Fukuoka, Japan) and H. Ishiwata (Nippon Oil Seal Industry Co., Ltd., Tokyo, Japan).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. GENERAL PAPERS. [A65-32761 21-15]

London, Institution of Mechanical Engineers, 1965, p. 138-147. 7 refs.

Establishment of a general formula for the value of  $\Psi$ , which was previously found to be dependent on the viscoelastic property of the seal material and the roughness of the sealing surface, by applying the theory of the foil bearing. Since the viscoelastic deformation of the lip is caused by sliding on peaks and valleys of the surface roughness, its significant effect should be taken into consideration. The result is given as  $\Psi = 2C(r/h_{\max})^{1/3}(h_{\max}/\lambda)^{2/3} \exp(\beta p_a J' A / h_{\max})$  where  $r$  is the radius of the shaft,  $h_{\max}$  the peak-to-valley height of the roughness of the shaft,  $\lambda$  the width of roughness,  $p_a$  the average contact pressure  $w/2\pi r$ ,  $J'$  the dynamic compliance of the lip, and  $C$  and  $\beta$  are constants. The theoretical relation not only gives a satisfactory explanation for experimental results, but also allows clarification of the limiting condition of the sealing action of a lip seal from a unified view with that of a mechanical seal. F.R.L.

#### A65-32770

##### ELASTOHYDRODYNAMIC BEHAVIOUR OBSERVED IN GEAR TOOTH ACTION.

Darle W. Dudley (Mechanical Technology, Inc., Latham, N.Y.).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. GENERAL PAPERS. [A65-32761 21-15]

London, Institution of Mechanical Engineers, 1965, p. 157-165. 11 refs.

Examination of several actual gear case histories to determine how the elastohydrodynamic theory of lubrication fits with the facts that have been observed. In the field of power gearing a wide variety of lubrication situations exist. Spur and helical gears running at high pitch-line velocity will operate for as much as a billion tooth contacts without enough wear occurring to remove machining marks 15-millionths of an inch deep. The teeth are apparently separated by an appreciable oil film. Slow speed gears with thin lubricants may wear as much as 1/8 in. in 10 million cycles of operation. F.R.L.

#### A65-32784 =

##### MAGNETOHYDRODYNAMIC EFFECT IN LUBRICATION. II - FULL JOURNAL BEARING WITH INERTIA EFFECTS.

J. P. Agarwal (Institute of Technology, Kharagpur, India).

Iasi, Institutul Politehnic, Buletinul, vol. 10, no. 1/2, 1964, p. 67-72. 5 refs.

Application of the momentum integral method to the investigation of the effect of a magnetic field on the load capacity of a full journal bearing in the case of an electrically conducting lubricant. It is found that load capacity depends on the Hartmann number, increasing with the magnetic field. Good agreement with results obtained for sliding bearings is noted. V. P.

#### A65-32933 =

##### RHEOLOGICAL ASPECT OF TOOL WEAR IN MACHINING GRAPHITE.

H. Takeyama (Government Mechanical Laboratory, Tokyo, Japan).

(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64-WA/prod-7.) ASME, Transactions, Series B - Journal of Engineering for Industry, vol. 87, Aug. 1965, p. 359-364. 8 refs.

Experimental analysis of the mechanism of tool wear, especially its speed effect, in machining graphite. When machining materials such as graphite and plastics, an interesting phenomenon is observed in the manner of tool wear: the faster the speed, the lower the rate of tool wear. To explain the relationship between tool wear and machining speed, it is assumed that the trailing portion of a rheological material in contact with a slider cannot follow the slider at higher sliding speeds because of its retardation of the elastic recovery. Considering the friction between graphite and tool, a decrease of the effective contact area between both, with an increase of the relative sliding speed must result in a decrease of the effective abrasive number of graphite; consequently, there must also result a decrease of the amount of tool wear, if the abrasives are distributed uniformly in the graphite material and the stresses on the contact area are almost constant regardless of sliding speed and contact area. M. M.

#### A65-32944

##### EFFECT OF TITANIUM ON THE RESISTANCE OF FERRITIC-AUSTENITIC STEELS TO INTERCRYSTALLINE CORROSION.

I. A. Levin and D. G. Kochergina (State Institute of Oil Machine Construction, USSR).

(Metallovedenie i Termicheskaya Obrabotka Metallov, Sept.-Oct. 1964, p. 22-25.)

Metal Science and Heat Treatment, Sept.-Oct. 1964, p. 602-605. Translation.

Discussion of the effect of titanium additions on the intercrystalline corrosion resistance of ferritic austenitic Kh21N5 and Kh21N6M2 steels after quenching at 950, 1050, and 1250°C. Titanium-free samples of both steels, containing 0.04 to 0.09% of carbon content, show prolonged resistance to intercrystalline corrosion, after quenching from 950°C. In contrast, samples with 0.284 to 0.61% Ti, even when they are resistant after additional heating at 450 to 850°C, rapidly lose this resistance at 1250°C. In weakly oxidizing media, the resistance decreases as the amount of ferrite in the samples increases. Titanium is found to promote ferrite formation, but slows down carbon diffusion and forms carbides during tempering. Titanium additions are found to be favorable only when the amount is precisely controlled. V. Z.

#### A65-32945

##### THE TITANIUM/CARBON RATIO IN STAINLESS STEELS.

M. B. Shapiro and I. G. Volikova (Scientific Research Institute of Chemical Machine Construction, Moscow, USSR).

(Metallovedenie i Termicheskaya Obrabotka Metallov, Sept.-Oct. 1964, p. 39, 40.)

Metal Science and Heat Treatment, Sept.-Oct. 1964, p. 619-621. 5 refs. Translation.

Discussion of the titanium/carbon ratio in stainless steels as a determining feature of intercrystalline corrosion resistance. The enhanced resistance is attributed to the ability of titanium to form carbides. Curves are presented of the variation of the amount of uncombined carbon with quenching temperature for different Ti/C ratios. Limit temperatures are shown up to which steels with a given Ti/C ratio can be heated without becoming susceptible to intercrystalline corrosion during subsequent tempering. V. Z.

#### A65-33125

##### LUBRICATION OF BALL BEARINGS IN HIGH SPEED APPLICATIONS.

Norton H. Goldstein (Boeing Co., Seattle, Wash.).

Engineering Materials and Design, vol. 8, July 1965, p. 470-472.

Account of the problems regarding the lubrication of high-speed ball bearings. The benefits of high-speed rotation and the role and method of lubrication are discussed, and types of lubricant and the effects of grease shear and oil churning are described. Best lubrication of a high-speed bearing is attained when the oil volume circulating over the bearing components is controlled so that just enough oil is applied to wet the rolling surfaces. Oil mist lubrication provides accurate control of the amount of oil delivered to a bearing by an oiler or wick; the oil used in an oil mist system should be a relatively low viscosity mineral oil. High-speed bearings can be harmfully affected by oil churning, as the internal friction in the bearing may cause heat rise, and it can retard free motion of the bearing elements. B.B.

## A65-33134

### A65-33134 #

#### THE POSSIBILITY OF SERVICE FAILURE OF STAINLESS STEELS BY STRESS CORROSION CRACKING.

J. E. Truman (Firth Brown, Ltd., Sheffield, England) and H. W. Kirkby (Firth Brown, Ltd., Research Laboratory, Sheffield, England).

*Metallurgia*, vol. 72, Aug. 1965, p. 67-71. 15 refs.

Review of the relative susceptibilities to stress-corrosion-cracking failure of the three basic types of stainless steel (austenitic, ferritic, and martensitic). It is concluded that, with the austenitic steels, cracking is a hazard only in special types of plant service at elevated temperatures, and that the steels can be used with complete safety for load-bearing applications at atmospheric temperatures. There is no stress corrosion hazard with the ferritic steels and little with the martensitics if they are softened to less than 65 to 70 tons/in.<sup>2</sup> tensile strength. (Author) R. A. F.

### A65-33218

#### ELASTOHYDRODYNAMIC LUBRICATION - AN INTRODUCTION AND A REVIEW OF THEORETICAL STUDIES.

D. Dowson (Leeds, University, Mechanical Engineering Dept., Leeds, England).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. NOTATION, REVIEW PAPERS, BIBLIOGRAPHY.

London, Institution of Mechanical Engineers, 1965, p. 7-16.

Study of situations in which the elastic deformation of the surrounding solids plays a significant role in the hydrodynamic lubrication process. Following consideration of the general features of the lubrication of line and point contacts, theoretical work is reviewed, with the comment that knowledge of elastohydrodynamics calls for an acquaintance with viscous flow, elasticity, thermodynamics, rheology, dynamics, and mathematics. Attention is given to film thickness and film shape, pressure distribution, surface tractions, stresses in the solids, side leakage, and point contacts. Lubricant properties are considered, and it is pointed out that many of the predictions of elastohydrodynamic theory have now been confirmed by experiment. It is considered that the theoretical results can be employed in the analysis of machine elements with some confidence. F. R. L.

### A65-33219

#### EXPERIMENTAL STUDIES OF ELASTOHYDRODYNAMIC LUBRICATION.

J. F. Archard (Leicester, University, Dept. of Engineering, Leicester, England).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. NOTATION, REVIEW PAPERS, BIBLIOGRAPHY.

London, Institution of Mechanical Engineers, 1965, p. 17-30.

Review of experimental studies of lubricated systems under concentrated load, with consideration of the parallel development of the theory. The discussion is concerned with those forms of experimental apparatus which attempt to produce simplified and well defined experimental conditions. Experimental techniques to measure film thickness and the analyses of such measurements are described. When measurements of conditions within the gap between the disks of a four-disk machine are made, conclusions can be drawn with reference to the shape of the film in line and point contact, as well as the pressure and temperature distribution. Friction and effective viscosity are examined, together with the effects of material properties. Problems of partial elastohydrodynamic lubrication and some applications are considered. F. R. L.

### A65-33220

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D. Dowson (Leeds, University, Mechanical Engineering Dept., Leeds, England) and J. F. Archard (Leicester, University, Dept. of Engineering, Leicester, England).

IN: ELASTOHYDRODYNAMIC LUBRICATION; SYMPOSIUM, LEEDS, ENGLAND, SEPTEMBER 21-23, 1965. NOTATION, REVIEW PAPERS, BIBLIOGRAPHY.

London, Institution of Mechanical Engineers, 1965, p. 31-35.

Bibliography of the symposium on elastohydrodynamic lubrication held in Leeds, England, from Sept. 21 to Sept. 23, 1965.

F. R. L.

### A65-33624 #

#### RESISTANCE SPOT WELDING OF TITANIUM ALLOY 8Al-1Mo-1V.

K. C. Wu and T. A. Krinke (Northrop Corp., Norair Div.,

Materials Research Group, Hawthorne, Calif.).

(American Welding Society, Annual Meeting, 46th, Chicago, Ill., Apr. 26-30, 1965, Paper.)

*Welding Journal, Research Supplement*, vol. 44, Aug. 1965, p. 365-s to 371-s. 6 refs.

Program for establishing the optimum welding conditions for one-sheet thickness (0.060 in.) through evaluation of the tension-shear, normal-tension, and fatigue strength of joints in resistance spot welding. The latter will be used extensively in the joining of skin and stringer structures for supersonic aircraft. The program includes the investigation of the effect of a corrosive environment under stress and thermal exposure without load on joint strength and microstructure. Using a single-phase ac resistance welding machine tension-shear and normal-tension specimens were fabricated to evaluate the joint strength and ductility at -165°F, room temperature, and 600°F. Since the shunting current was not a problem with this alloy, minimum spot spacing was determined by residual stress measurements using a photo-stress analysis technique. The fatigue strength at room temperature of single- and multiple-spot welds was determined and correlated to residual stress. Stress-corrosion properties in the 400 to 700°F temperature range were evaluated; and the microstructural stability of welds exposed in air and in argon at 600°F for periods of 500 and 1000 hr was studied.

(Author) D. P. F.

### A65-33627

#### CARBON-FUNCTIONAL ORGANOSILICON FLUOROESTERS AS SYNTHETIC LUBRICANTS.

Paul M. Kerschner (Cities Service Research and Development Co., Cranbury, N. J.).

(American Chemical Society, Meeting, 148th, Chicago, Ill., Sept. 1964, Paper.)

*I & EC - Industrial and Engineering Chemistry, Product Research and Development*, vol. 4, Sept. 1965, p. 197-200. 6 refs.

Effort to combine the best lubricant product characteristics of the esters, the silicones, and the fluorinated hydrocarbons into a single molecular species which resulted in the synthesis of a class of compounds known as carbon-functional organosilicon fluoroesters. The purified products possess good viscosity-temperature characteristics over wide temperature ranges, low pour points, and good lubricity at moderate and extreme pressures. Oxidation and corrosion stability have been demonstrated at 350°F, and the resistance to coke formation at 590°F would seem to indicate oxidation stability at temperatures in excess of 350°F. Thus, the experimental results confirmed the basic assumption motivating this research.

(Author) M. F.

### A65-33851 #

#### THE MAGNETOHYDRODYNAMIC PARALLEL PLATE SLIDER BEARING.

D. C. Kuzma (General Motors Corp., Research Laboratories, Warren, Mich.).

(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N. Y., Nov. 29-Dec. 4, 1964, Paper 64-WA/Lub-2.)

*ASME, Transactions, Series D - Journal of Basic Engineering*, vol. 87, Sept. 1965, p. 778-780.

Analytical investigation of the effect of a nonuniform applied magnetic field on the operation of a parallel plate slider bearing. It is found that the optimum magnetic field profile is a step function. This profile increases the load-carrying capacity, while decreasing the friction factor. The results are said to indicate that the nonuniform applied magnetic field is definitely superior to the uniform applied magnetic field, and that the operating characteristics of magnetohydrodynamic bearings may be improved by a nonuniform applied magnetic field. (Author) M. M.

**A65-33852 =****CALCULATION OF WEAR RATE.**

I. V. Kraghelsky (Academy of Sciences, Research Institute of Mechanical Engineering, Moscow, USSR).

(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64-WA/Lub-5.)

ASME, Transactions, Series D - Journal of Basic Engineering, vol. 87, Sept. 1965, p. 785-790. 16 refs.

Presentation of exhaustive analytical data on factors contributing to the wear of a deformed body interacting with an absolutely rigid rough solid. It is believed that wear results from the deformation of a body due to geometrical and mechanical factors and due to its adhesion bonds. Three types of wear are considered: by elastic deformation, by plastic deformation, and by microcutting. The suggested criteria allow the determination of conditions which cause these types of wear to appear. It is shown that the rate of wear - i.e., the ratio of height of the worn layer to the distance of sliding at elastic contact - depends on the elasticity modulus, roughness, friction coefficient, nominal pressure, rupture stress of material, and on the power exponent of the fatigue curve. In plastic contact it depends on the roughness, nominal pressure, hardness, destroying deformation, and the friction coefficient. In microcutting, it depends on roughness, nominal pressure, and hardness. Wear in microcutting is found to be independent of the friction coefficient. The formulas derived are borne out by experiments. These formulas may be readily modified for the case of two rough surfaces. (Author) M.L.

**A65-33853 =****LUBRICATION REVIEW.**

T. E. Timkens (U.S. Army, Watervliet Arsenal, Watervliet, N.Y.), R. D. Brown, R. A. Burton (Southwest Research Institute, San Antonio, Tex.), E. E. Klaus (Pennsylvania State University, College of Engineering, Dept. of Chemical Engineering, Petroleum Refining Laboratory Div., University Park, Pa.), W. J. Wojtowicz (H. A. Montgomery Co., Detroit, Mich.), and F. J. Villforth, Jr. (Texaco, Inc., Research Center, Beacon, N.Y.). (American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64-WA/Lub-1.) ASME, Transactions, Series D - Journal of Basic Engineering, vol. 87, Sept. 1965, p. 791-804. 150 refs.

Presentation of information on publications relating to several aspects of the field of lubrication. Many of the results of current theoretical and experimental investigations are summarized. The areas reviewed include fluid-film lubrication, developments in lubricants, metalworking lubricants, automotive lubricants, gear lubrication, boundary lubrication, rolling element bearings, and friction and wear. (Author) M.L.

**A65-33854 =****MAGNETOHYDRODYNAMIC SQUEEZE FILM BEARINGS.**

F. T. Dodge (Southwest Research Institute, Dept. of Mechanical Sciences, San Antonio, Tex.), J. F. Osterle, and W. T. Rouleau (Carnegie Institute of Technology, Dept. of Mechanical Engineering, Pittsburgh, Pa.).

(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 4, 1964, Paper 64-WA/Lub-3.)

ASME, Transactions, Series D - Journal of Basic Engineering, vol. 87, Sept. 1965, p. 805-809. 6 refs.

Theoretical analysis of squeeze film bearings which use an electrically conducting fluid, such as a liquid metal, as the lubricant, and which are in the presence of a magnetic field. Electrical energy is added to the film by an exterior source. By considering infinitely long rectangular plates, the fluid film thickness is determined as a function of time, with the applied magnetic and electric fields as parameters. It is shown that the squeeze action is altered significantly when the electric field is symmetrical about the center of the bearing, and results are presented for various values of the Hartmann number. (Author) M.M.

**A65-34699****EXTENSION OF DRAIN PERIODS IN GAS TURBINE ENGINES USING IMPROVED SYNTHETIC LUBRICANTS.**

H. W. Reynolds, Jr. (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).

Society of Automotive Engineers, National Aeronautics and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 4-8, 1965, Paper 650814. 11 p.

Members, \$0.75; nonmembers, \$1.00.

Analysis of the so-called "constant oil-monitoring system" which uses an electrical conductivity tester with Type 2 oils and provides a practical, sensitive, and low-cost means of extending oil life without fixed use-time limitations. A brief history of the development of lubricants is traced, and basic performance criteria and methods used for extending oil life are given. Potential benefits to airlines through use of the constant oil-monitoring system are outlined.

B.B.

**A65-34831****MULTIPURPOSE AERONAUTICAL LUBRICATING GREASES.**

M. J. Devine, E. R. Lamson, and L. Stallings (U.S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.).

Society of Automotive Engineers, National Aeronautics and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 4-8, 1965, Paper 650817. 7 p.

Members, \$0.75; nonmembers, \$1.00.

Description of the use and limitations of a range of aeronautical lubricating greases specified for military vehicles and components. Sixteen greases are evaluated, and important properties of 11 of the more generally used greases are tabulated. Because of problems presented by the increasing number of different greases required for the variety of vehicles and components, a program has been initiated to establish possibilities for multipurpose greases, and various consolidations have been effected. It is anticipated that within five years the number of greases required may be reduced to two.

F.R.L.

**A65-34836****A NEW HIGH TEMPERATURE BEARING MATERIAL.**

Mukul K. Mukherjee (Midwest Research Institute, Kansas City, Mo.).

Society of Automotive Engineers, National Aeronautics and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 4-8, 1965, Paper 650796. 7 p. 21 refs.

Members, \$0.75; nonmembers, \$1.00.

Characteristics of new bearing materials, suitable for high-temperature applications, which possess preferred lattice structural properties and appear to exhibit low friction and wear coefficients. Materials evaluated were MgNi, MgNi<sub>2</sub>, Ni<sub>2</sub>Al<sub>3</sub>,  $\alpha$ -Ti (Ti + Al), TiAl<sub>3</sub>, and  $\beta$ -Co (Co + Zn). Friction and wear characteristics were determined on a pellet friction machine at a linear surface speed of 580 fpm at temperatures up to 1000°F in air or N<sub>2</sub>. The coefficient of friction is determined by measurement of the torque necessary to drive the pellet holder on its axis. The most feasible manufacturing method appears to be sintering, provided the smallest available particle size powders are sintered directly in a mold designed to give the same shape as the bearing and provided the method is selected so that the matrix has a low porosity and limited particle growth. Future advancement of the bearing is considered to lie in the possibility of using a suitable precipitation hardenable high-temperature material, thus ensuring good maintenance characteristics and reliability.

F.R.L.

**A65-34839****AIR TRANSPORT LANDING GEAR MAINTENANCE.**

William W. Witt (United Air Lines, Inc., Elk Grove Township, Ill.).

Society of Automotive Engineers, National Aeronautics and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 4-8, 1965, Paper 650842. 6 p.

Members, \$0.75; nonmembers, \$1.00.

Airline experience regarding landing gear design and maintenance, with suggestions to assist design engineers in prevention of some of the problems encountered. The necessity for large radii on corners to prevent cracks is stressed. Material which is tolerant of some nicks and scratches should be chosen, and troubles arising from overzealous attempts to save weight are discussed. Joints and bushings should be as few as possible and adequately protected against corrosion. Accurate identification of parts is important. Lubrication and hydraulic seal leakage problems are examined, and the importance of simple design is emphasized.

F.R.L.

**A65-34857 \***

PATTERN-CONFORMING CRACKING OF AN OXIDE FILM ON ALUMINUM DURING HIGH-TEMPERATURE OXIDATION [ZAKONOMERNOE RASTRESKIVANIE OKISNOI PLENKI NA ALIUMINII PRI VYSOKOTEMPÉRATURNOM OKISLENII].

Iu. D. Chistiakov and A. Iu. Mendelevich (Moskovskii Institut Stali i Splavov, Kafedra Proizvodstva Chistykh Metallov i Poluprovodnikovykh Materialov, Moscow, USSR).

*Tsvetnaia Metallurgii*, vol. 8, no. 3, 1965, p. 127-130. 22 refs. In Russian.

Investigation of the process of pattern-conforming cracking of an oxide film on aluminum occurring during high-temperature oxidation and resulting from oriented growth of the film on the surfaces of the metal grains. The driving force of this process is found to be the energy field of the crystal lattice of the metal and diffusion of hydrogen atoms from the metal into the oxide film. The assumption, on the part of a number of authors, that a good crystallochemical correspondence exists between aluminum and the  $\gamma$ -oxide of aluminum is shown to be false. Pattern-conforming cracking of an oxide film is said to be the cause of the decrease in corrosion resistance of welded seams and articles made of pure aluminum subjected to high-temperature heat treatment.

A. B. K.

**A65-34961**

HIGH-ALLOY STEELS.

E. A. Schoefer (Alloy Casting Institute, New York, N. Y.).

*Machine Design*, vol. 37, Sept. 9, 1965, p. 19-24.

Review of the properties of "high-alloy" steel castings, which contain at least 8% nickel and/or chromium. These alloys are used to resist corrosion and provide strength at temperatures above 1200°F. The physical and mechanical properties of both corrosion-resistant and heat-resistant cast high alloys are described, and techniques for casting and fabricating them are discussed.

P. K.

**A65-34977**

INFLUENCE OF THE DEGREE OF DEFORMATION AND THE ANNEALING TEMPERATURE ON THE ELECTROCHEMICAL CORROSION OF TITANIUM AND AN ALLOY OF TITANIUM WITH 0.2% PALLADIUM.

N. D. Tomashov and Iu. M. Ivanov (Akademiia Nauk SSSR, Institut Fizicheskoi Khimii; Gosudarstvennyi Nauchno-Issledovatel'skii i Proektnyi Institut Redkometallicheskoii Promyshlennosti, Moscow, USSR).

(*Zashchita Metallov*, no. 1, 1965, p. 36.)

*Protection of Metals*, no. 1, 1965, p. 40-45. Translation.

Study of the effects of deformation and annealing on the corrosion resistance of pure and alloyed titanium in sulphuric and hydrochloric acids. The alloy tested was titanium, 0.2% palladium. It is found that cold-rolled sheets of the pure and alloyed titanium have lower corrosion rates in the rolling plane than annealed sheets and that the rate of corrosion in this plane decreases with increasing deformation. The annealing of deformed sheets at temperatures below 600°C had no effect on the corrosion resistance, while increasing the temperature above 600°C increases the corrosion rate. The welding of unannealed sheets leads to an increased corrosion rate of the weld seams and the area near the weld zone.

P. K.

**A65-34980**

A RADIOCHEMICAL METHOD OF INVESTIGATING THE MECHANISM OF THE PROTECTIVE EFFECT OF PALLADIUM IN THE CORROSION RESISTANT ALLOYS TITANIUM-PALLADIUM.

N. D. Tomashov, M. N. Shchulepnikov, and Iu. M. Ivanov (Akademiia Nauk SSSR, Institut Fizicheskoi Khimii; Gosudarstvennyi Nauchno-Issledovatel'skii i Proektnyi Institut Redkometallicheskoii Promyshlennosti, Moscow, USSR).

(*Zashchita Metallov*, no. 1, 1965, p. 122.)

*Protection of Metals*, no. 1, 1965, p. 133-135. 5 refs. Translation.

Study, using a radiochemical method, of the mechanism by which the addition of palladium increases the corrosion resistance of titanium. Specimens of annealed Ti, 0.1% Pd are treated in a boiling solution of 5% HCl and then irradiated for 20 hr with a flux of slow neutrons which transforms the Pd 108 inside the alloy into radioactive Pd 109, which can be traced. Some control specimens are not immersed in the HCl. It is found that treating specimens with HCl increases the quantity of palladium at the surface at least

15 times. It is suggested that this accounts for the sharp weakening of the cathode reaction due to passivation following the introduction of even very small quantities of palladium into titanium.

P. K.

**A65-35056 #**

HIGH-STRENGTH HIGH-ALLOY STEELS.

C. L. M. Cottrell (Bristol Aerojet, Ltd., Rocket Motor Dept., Banwell, Soms., England).

*Chartered Mechanical Engineer*, vol. 12, Sept. 1965, p. 440-445, 456.

Discussion of the characteristics of high-strength high-alloy steels. Strengths of various alloy steels are studied and tabulated, and toughness of high-tensile steel is considered. The effect of melting and alloying processes on fracture toughness is plotted, and the fatigue properties of high-strength steels are evaluated. Finally, corrosion and heat-resistant steels and machining and forming methods are analyzed. It is concluded that the maximum strength of high-alloy steels has greatly increased in recent years and that current developments are mostly aimed at combining this with greater toughness, better working properties, and higher corrosion resistance.

B. B.

**A65-35750**

SOME AIRCRAFT CORROSION PROBLEMS AND THEIR SOLUTIONS.

Morgan Sinclair (Douglas Aircraft Co., Inc., Aircraft Div., Chemical Section, Long Beach, Calif.) and Robert H. Gassner (Douglas Aircraft Co., Inc., Metals Section, Long Beach, Calif.). (*National Association of Corrosion Engineers, Western Region Conference, Anaheim, Calif., Sept. 25-27, 1963, Paper.*)

*Materials Protection*, vol. 4, Oct. 1965, p. 69-73.

Description of several case histories of corrosion failures in aircraft, and discussion of what was done in each case to remedy the situation or prevent future occurrences. Among items discussed are hydraulic lines, angle-of-attack indicator, hot air ducting, control cable, and bellows. It is briefly explained what procedures were taken to prevent further failures.

(Author) M. F.

**A65-36014 #**

EFFECT OF ALUMINUM ADDITIONS ON THE CORROSION RESISTANCE OF TITANIUM IN SULFURIC ACID SOLUTIONS [VLIYANIE LEGIROVANIA ALIUMINIEM NA KORROZIONNIU STOIKOST' TITANA V RASTVORAKH SERNOI KISLOTY].

G. M. Kirkin and N. R. Zhuk.

*Zashchita Metallov*, vol. 1, July-Aug. 1965, p. 380-384. 8 refs. In Russian.

Investigation of the effect of 0.1, 0.3, 0.6, 1.0, 3.0, and 5.0% Al additions on the corrosion resistance and electrochemical characteristics of titanium at 25 to 80°C in 5 to 80% H<sub>2</sub>SO<sub>4</sub>. It is found that (1) corrosion of titanium and its alloys with aluminum in H<sub>2</sub>SO<sub>4</sub> is a steadily progressing process, (2) Al additions, especially up to 1%, reduce the corrosion resistance of titanium, (3) the temperature and the concentration of H<sub>2</sub>SO<sub>4</sub> have similar effects on the corrosion rates of pure titanium and its alloys with aluminum, and (4) the inferior protective properties of films that are formed on alloy surfaces reduce the corrosion resistance of Ti-Al alloys.

V. Z.

**A65-36015 #**

QUANTITATIVE ESTIMATE OF THE CORROSION FATIGUE OF METALS [K VOPROSU O KOLICHESTVENNOI OTSENKE KORROZIONNOI USTALOSTI METALLOV].

V. V. Romanov (Akademiia Nauk SSSR, Institut Metallurgii, Moscow, USSR).

*Zashchita Metallov*, vol. 1, July-Aug. 1965, p. 391-395. In Russian.

Discussion of the reliability, as criteria of corrosion fatigue, of the "conditional" limit of corrosion fatigue,  $\sigma_{-1}^k$ , and the ratio between the limits of corrosion fatigue and pure fatigue,  $\sigma_{-1}^k/\sigma_{-1}^b$ , found from the curve for the number of cycles to failure vs load. The conclusions are drawn that (1)  $\sigma_{-1}^k$  in no way characterizes corrosion fatigue and measures only the remainder of the cyclic strength of a metal, and (2)  $\sigma_{-1}^k/\sigma_{-1}^b$  and the area between the curves for pure fatigue and corrosion fatigue are better quantitative criteria of corrosion fatigue.

V. Z.

**A65-36016 =**

SOME PROBLEMS IN CALCULATING THE CONTACT CORROSION FOR A PLANE AND CYLINDRICAL METALLIC SURFACE [NEKOTORYE ZADACHI RASCHETA KONTAKTNOI KORROZII PLK KOI TSILINDRICHESKOI POVERKHNOSTI METALLA].

Iu. Ia. Iossel', E. S. Kochanov, and M. G. Strunskii (Tsentr. nauchno-issledovatel'skii Institut, Leningrad, USSR).

*Zashchita Metallov*, vol. 1, July-Aug. 1965, p. 410-419. 7 refs. In Russian.

Derivation of simple approximate expressions for the voltage and density of the contact-corrosion current arising at the contact surface of two different metals. The expressions apply to plane and cylindrical contact surfaces, uncoated or coated with a dielectric dye, and can be used for calculating anticorrosion systems in engineering construction designs. As a numerical example, a determination is made of the density of the contact-corrosion current at a point on the surface of a dye-coated high-carbon steel sheet in contact with a dye-coated bronze sheet in soil. V. Z.

**A65-36165 =**

BEARING ALLOYS CONTAINING SOLID LUBRICANTS - FRICTION TESTS OVER THE RANGE 20-400°C.

E. A. Smith.

*Metallurgia*, vol. 72, Sept. 1965, p. 119, 120.

Observation that a proprietary alloy containing graphite and molybdenum disulphide offered a very low coefficient of friction, which was maintained at temperatures up to 400°C. Details of the experiments are described and results are summarized.

(Author) M. F.

**A65-36334**

OXIDATION OF METALS.

Karl Hauffe.

(Translation of *Oxydation von Metallen und Metallegierungen*, Berlin, Springer-Verlag, 1956).

New York, Plenum Press, 1965. 452 p. \$19.50.

This book begins with a critical review of structural defects in scaling layers formed in the process of metal oxidation, since it is these defects in the protective layers that determine the mechanism and rate of oxidation, at least in those cases where diffusion or transport processes are rate-determining. This approach leads to a classification of oxidation processes from the point of view of the theory of defects in the layer of reaction products and of the associated kinetics, in place of the more familiar chemical classification as oxidation, sulfuration, halogenation, etc. Since this classification is applicable only when the rate of oxidation is not determined by a phase-boundary reaction, it has to be subordinated to a more general one, namely, that of oxidation processes controlled on the one hand by transport phenomena and on the other hand by phase boundary reactions. The author feels that a detailed treatment of the basic, generally valid elementary processes of metal oxidation is of greater value than a comprehensive reporting of the mass of published results. For this reason many reports on the oxidation of alloys of industrial interest have not been cited. However, it is hoped that this weakness is counterbalanced by the fundamental nature of the discussion of the possible reactions leading to the formation of protective layers on metals. The book is intended to stimulate professional colleagues employed in industry to further significant experimentation. M. F.

L. I. Pugina, I. M. Fedorchenko, and N. E. Ponomarenko (Akademiia Nauk Ukrainskoi SSR, Institut Problem Materialovedeniia, Kiev, Ukrainian SSR).  
*Poroshkovaia Metallurgii*, vol. 5, Sept. 1965, p. 53-57. 6 refs. In Russian.

Investigation of the effect of graphite content (from 20 to 90 vol%) on the antifriction properties of graphitized nickel-based (50 to 80% Ni) copper and iron alloys. The technique of preparation of the materials and the experimental procedure are described. Metal-graphite materials with up to 50 vol% of graphite content are found to resist well high-rate sliding friction with limited lubrication but lose strength quickly at higher graphite contents. Materials with 50 to 90 vol% of graphite content have a high dry friction coefficient (0.22 to 0.40) which restricts their use without lubrication. Depending on the composition, the friction coefficient varies from 0.03 to 0.06 at friction rates to 50 m/sec and loads from 3.3 to 3.8 kg/cm<sup>2</sup>-sec when the materials investigated perform with lubrication.

V. Z.

**A66-10821**

A LOOK AT THE MIL-L-23699 (WEP) LUBRICANTS.

A. G. Sundberg and E. H. Wehner (General Electric Co., Flight Propulsion Div., West Lynn, Mass.).

*Society of Automotive Engineers, National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 4-8, 1965, Paper 650816*. 12 p.

Members, \$0.75; nonmembers, \$1.00.

Laboratory, component, and engine tests conducted to evaluate the various lubricant properties important to the J79 jet engine. Such properties as elastomer volume swell, oxidation-corrosion, coking characteristics, and lubricity were evaluated. The effects of these various properties on engine performance and how the laboratory results relate to the component results and engine test results are discussed. M. F.

**A66-10987 #**

ELECTROCHEMICAL STUDY OF THE EFFECT OF CARBON, TITANIUM AND MANGANESE CONTENT ON THE CORROSION RESISTANCE OF CHROMIUM-NICKEL-MANGANESE STEELS. 1 - ANODE BEHAVIOR [ELEKTROKHMICHESKOE ISSLEDOVANIE VLIIANIIA SODERZHANIIA UGLERODA, TITANA I MARGANTS NA KORROZIONNUIU STOIKOST' KHROMONIKEL' MARGANTSEVYKH STALEI. 1 - ANODNOE POVEDENIE].

V. M. Kniazheva, M. A. Vedeneva, Said Esel'din Khalil', and Ia. M. Kolotyarkin (Nauchno-issledovatel'skii Fiziko-Khimicheskii Institut, Moscow, USSR).

*Zashchita Metallov*, vol. 1, Sept.-Oct. 1965, p. 465-472. 20 refs. In Russian.

Investigation of the effect of variations in nickel content (reduction to 5%) and manganese content (5 and 10%) on the anodic behavior of Kh18N9 steels. It is shown that (1) the reduction of Ni content to 5% and the introduction of 10% Mn have no effect on the solubility rate of Kh18N9 steels at potentials from -0.05 to 1.35 v which include the region of a stable passive state, (2) in the region of secondary passivation of these metals, anodic oxidation of manganese reduces the solubility rate as the potential increases, and (3) the resistance to intercrystallite corrosion is higher in steels of this type having an austenitic-ferrite structure. Reduction of carbon content, rather than stabilization with titanium, is seen to be preferable as a remedy against intercrystallite corrosion. V. Z.

**A66-10988 #**

GAS CORROSION OF AUSTENITIC-FERRITE STEELS [GAZOVAIA KORROZIJA AUSTENITO-FERRITNYKH STALEI].

A. A. Grigor'eva, N. P. Zhuk, and G. G. Sergeeva (Moskovskii Institut Stali i Splavov, Moscow, USSR).

*Zashchita Metallov*, vol. 1, Sept.-Oct. 1965, p. 490-493. 10 refs. In Russian.

Investigation of the heat resistance in air of four industrial austenitic-ferrite steels (0Kh21N5MD2T, 0Kh21N6M2T, 1Kh21N5T, 0Kh21N5T) with low nickel content (5.3 to 6.7%) at temperatures gradually raised from 750 to 1050°C. The oxide films are examined with X rays, and curves are included showing the temperature-dependent rate of scale formation determined by systematically weighing the samples during the heating. The results, compared with those for two one-phase austenitic steels (Kh18N9T, Kh18N12M2T) with 10.2 and 12.3% Ni, show that the ferrite phase has a negative

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## IAA ENTRIES

**A66-10745 #**

EFFECT OF GRAPHITE CONTENT ON THE ANTIFRICTION PROPERTIES OF METAL-GRAPHITE MATERIALS [VLIANIE SODERZHANIIA GRAFITA NA ANTIFRIKTSIONNYE SVOISTVA METALLOGRAFITOVYKH MATERIALOV].



## A66-10990

effect on the heat resistance of these steels. The negative effect of molybdenum and the positive effect of chromium are also noted.

V. Z.

## A66-10990 #

CORROSION OF TITANIUM IN MANGANESE-AMMONIUM SULFATE SOLUTIONS [KORROZIJA TITANA V SUL'FATNOM MARGANTSEVO-AMMONIINOM RASTVORE].

E. D. Chkhikvadze (Akademii Nauk Gruzinskoi SSR, Institut Neorganicheskoi Khimii i Elektrokhimii, Tiflis, Georgian SSR). *Zashchita Metallov*, vol. 1, Sept.-Oct. 1965, p. 595-597. 5 refs. In Russian.

Investigation of the corrosion rate of BT-1 titanium and 9Kh18N12M2T stainless steel at 22 to 24°C in electrolyte containing 110 g/liter of  $MnSO_4 \cdot 5H_2O$  and 150 g/liter of  $(NH_4)_2SO_4 \cdot 600$ -hr tests, using the gravimetric method to determine the change in weight of samples, showed a high corrosion resistance of both metals. Curves of corrosion rate vs pH (2 to 8), anodic polarization vs pH (3 to 7), and time-dependent variations in the potential are included to illustrate the results.

V. Z.

## A66-11181 #

DETERMINATION OF THE CHARACTERISTICS OF A CIRCULAR, FLEXIBLE PLATE, ALLOWING FOR THE FORCES OF CLAMPING FRICTION [OPREDELENIE KHKAKTERISTIKI KRUGLOI GIBKOI PLASTINKI S UCHETOM SIL TRENIIA V ZADELKE].

I. I. Sherstobitov.

IN: PROBLEMS OF DYNAMICS AND STABILITY [VOPROSY DINAMIKI I PROCHNOSTI].

Edited by Ia. G. Panovko.

Riga, Latvian SSR, Izdatel'stvo Akademii Nauk Latviiskoi SSR, 1964, p. 159-172. 8 refs. In Russian.

Derivation of expressions to describe the characteristics of a flexible, round plate, taking account of deformation in the clamped section arising from friction forces. Stress and strain in the friction zone are considered, and Hencky's (1915) solution for the stress and deflection of a membrane is modified. An asymptotic solution to the equation for large deflections of a flexible plate is worked out. All solutions are based on the construction-deformation theories of Kalinin, Lebedev, and Lebedeva (1960) and Panovko (1960). R. A. F.

## A66-11182 #

DETERMINATION OF THE CHARACTERISTICS OF A CORRUGATED MEMBRANE, ALLOWING FOR THE EFFECT OF THE FORCES OF CLAMPING FRICTION [OPREDELENIE KHKAKTERISTIKI GOFRIROVANNOI MEMBRANY S UCHETOM VLIIANIIA SIL TRENIIA V ZADELKE].

I. I. Sherstobitov.

IN: PROBLEMS OF DYNAMICS AND STABILITY [VOPROSY DINAMIKI I PROCHNOSTI].

Edited by Ia. G. Panovko.

Riga, Latvian SSR, Izdatel'stvo Akademii Nauk Latviiskoi SSR, 1964, p. 173-190. 5 refs. In Russian.

Detailed analysis of the forces acting on a partially clamped, corrugated membrane, taking account of clamping friction. The clamped ring and some characteristics of the membrane are calculated for cases of complete and incomplete loading. A sample problem is worked out.

R. A. F.

## A66-11304 #

INFLUENCE TO PROPERTIES BY DIFFERENT HEAT TREATMENT CYCLE FOR AM 355. I.

Kenji Hashimoto (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan).

*Ishikawajima-Harima Engineering Review*, vol. 5, July 1965, p. 395-402. 7 refs. In Japanese.

Analysis of the results of five experiments for determining the effects of various heat-treatment cycles on the final mechanical properties of a corrosion-resistant precipitation-hardened steel (AM 355), in terms of its metallographic structure. This metal is under consideration for use in SST jet engines. Precipitation-hardening effects on corrosion resistance and tensile strength have, it is pointed out, posed an interesting problem. By control of the heat-treatment cycles, AM 355 can be made suitable for various applications - by affecting the presence and distribution of coherent and incoherent precipitation and structure transformations.

F. R. L.

## A66-11698 #

LIQUID METAL EMBRITTLEMENT.

R. C. Carlston (U.S. Navy, Office of Naval Research, Metallurgy Branch, Washington, D. C.).

*Naval Research Reviews*, vol. 18, Sept. 1965, p. 1-8.

Examination of the essential factors of liquid metal embrittlement. The background of this phenomenon is briefly discussed, and characteristics of the intergranular corrosion mode are considered, together with the environmental cracking modes. Some specific liquid-solid embrittlement couples are tabulated, as are the factors and problems in liquid metal embrittlement, the effect of aqueous solutions on mechanical behavior of AgCl crystals, and the common factors in environmental cracking. It is concluded that the interpretation of all environmental cracking modes is still in a state of flux, despite the attention given to it in recent years.

B. B.

## A66-11742

NON-METALLIC MATERIALS - NUCERITE.

W. Wood (Balfour Group, Leven, Scotland).

IN: NEW ENGINEERING MATERIALS; CONFERENCE, BIRMINGHAM, ENGLAND, OCTOBER 13, 14, 1965. [A66-11736 02-17] London, Institution of Mechanical Engineers, 1965, p. 92-98.

This paper describes "Nucerite," a new material of construction consisting of a ceramic-metal composite which has improved mechanical strength and abrasion resistance over glassed steel. A wide range of ceramics is available and these can be bonded to a range of base metals, thus giving a very wide choice of properties. An outline of the induced crystalline structure in the ceramic shows how Nucerite is suitable for high temperature use together with good corrosion resistance. The application of Nucerite in the chemical and related industries shows how its versatility can be used to solve high temperature, corrosion, and abrasion problems. Examples of items of equipment, together with the conditions under which they are being used, confirms that there is a big future for Nucerite as it is developed and its properties are improved even further.

(Author)

## A66-12249

EFFECT OF VARIOUS LUBRICANTS AND BASE MATERIALS ON FRICTION AT ULTRAHIGH LOADS.

K. E. Demorest and A. F. Whitaker (NASA, Marshall Space Flight Center, Propulsion and Vehicle Engineering Laboratory, Materials Div., Huntsville, Ala.).

*American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-23. 11 p. 5 refs.*

A series of high load, low-speed sliding friction tests was made on eight greases and eighteen dry lubricants at normal unit loads from 10,000 psi to 150,000 psi. Four different substrate materials were used having a range of hardnesses from Rockwell C 18 to Rockwell C 55. The ultimate load capability of both greases and dry films is a function of substrate hardness with the best ultimate load capability being provided by inorganically bonded molybdenum disulfide films with small amounts of graphite added. The coefficient of friction of the greases appears to be an inverse function of substrate hardness and a direct function of the normal load. The coefficient of friction of the dry lubricants is an inverse function of the normal load, but does not appear to be related to the substrate hardness.

(Author)

## A66-12251

SLIDING BEHAVIOR OF SOME LAYER LATTICE COMPOUNDS IN ULTRAHIGH VACUUM.

A. J. Haltner (General Electric Co., Missiles and Space Div., Space Sciences Laboratory, Philadelphia, Pa.).

*American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-19. 12 p. 23 refs. Contract No. AF 33(657)-10493.*

Friction measurements have been made on a series of layer lattice compounds selected from a number of different crystal systems. Experiments in ultrahigh vacuum confirm the vapor lubrication mechanism for natural graphite, pyrolytic graphite, and boron nitride. For all other lamellar solids studied there was no evidence that vapor lubrication played a role in the sliding mechanism. It is likely that vapor lubrication applies to lamellar solids only when relatively high specific forces are acting between the layers.

(Author)

**A66-12252****FRICITION AND WEAR OF HEXAGONAL METALS AND ALLOYS AS RELATED TO CRYSTAL STRUCTURE AND LATTICE PARAMETERS IN VACUUM.**

Donald H. Buckley and Robert L. Johnson (NASA, Lewis Research Center, Cleveland, Ohio).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-18, 13 p. 32 refs.

The friction and wear characteristics were determined for fourteen hexagonal metals in vacuum at temperatures to 850°F and sliding speeds to 2000 fpm. The metals examined included cobalt, titanium, zirconium, hafnium, beryllium, the rare earth metals, and binary alloys of some of these with other elements. Single crystals of cobalt were also examined to determine the influence of specifically oriented planes on friction. Differences in friction properties of these metals (e.g., cobalt and titanium) were found to be related to crystal slip systems and associated shear. Friction coefficients are further related to lattice parameters for fourteen hexagonal metals. For those hexagonal metals undergoing crystal transformation to a cubic form at elevated temperatures, marked changes were observed in friction and wear with the crystal transformation. While relatively moderate friction and wear is observed for the hexagonal form, high friction and complete welding is observed for the cubic structures. Selective alloying of other elements with these hexagonal metals was found to expand the crystal lattice and to delay crystal transformation, thereby improving friction and wear characteristics. (Author)

**A66-12253****ANALYTICAL ASPECTS OF GEAR LUBRICATION ON THE DIS-ENGAGING SIDE.**

J. W. McCain and E. Alsandor (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-16, 10 p. 5 refs.

Variations and inconsistencies in the ratings of rocket engine lubricating oils on the Ryder Gear Tester prompted an analytical investigation into the mechanism of lubrication. It is considered that gears are lubricated on the disengaging side primarily to rapidly dissipate frictional heat. Based on this consideration, it is contended that oil nozzle position and depth of oil impingement are important variables. It is analytically shown by using the Ryder gears how these important variables could contribute to the load-carrying ability of oils and how these contributions could affect the Ryder ratings of oils. (Author)

**A66-12254****STUDY OF CORROSIVITY AND CORRELATION BETWEEN CHEMICAL REACTIVITY AND LOAD CARRYING CAPACITY OF OILS CONTAINING EXTREME PRESSURE AGENTS.**

Toshio Sakurai (Tokyo Institute of Technology, Tokyo, Japan) and Kachio Sato (Nippon Mining Co., Ltd., Central Research Laboratory, Toda-machi, Saitama-ken, Japan).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-11, 10 p. 8 refs.

The work to be described in this paper, is a study of chemical reaction between iron surfaces and various representative extreme pressure (EP) agents, such as chlorine type, sulfur type, Zn-dithiophosphate type, and the mixture of sulfur and chlorine type EP agents, by using the hot wire method. It has been observed that the corrosion rate of iron follows the parabolic law or the cubic law. The parabolic law can be explained by the diffusion mechanism of corrosion. In order to explain the cubic law, the corrosion retarding action of a barrier film has been assumed. From the X-ray analysis of reaction products, the complexity of corrosion process has been revealed. Zinc-diisobutyldithiophosphate has shown the characteristic behavior in the corrosion process showing retardation against the corrosion. With a binary additives system, the joint reaction of sulfur and chlorine compounds on iron could not be satisfactorily supported in the scope of this study. Some interesting considerations are given for the correlation between chemical reactivity and load carrying capacity of oils containing EP agents. (Author)

**A66-12255****RESEARCH AND DEVELOPMENT OF MATERIALS FOR USE AS LUBRICANTS IN A LIQUID HYDROGEN ENVIRONMENT.**

W. H. Rempe, Jr. (United Aircraft Corp., Pratt and Whitney Aircraft Div., Florida Research and Development Center, West Palm Beach, Fla.).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-9, 9 p. 9 refs.

Contract No. NAS 8-11537.

A program was conducted to evaluate materials that could be used as lubricants in rolling-contact bearings operating in a liquid hydrogen environment at DN values up to 4 million mm-rpm. A unique ball and plate test apparatus was used to test twenty candidate lubricant materials selected for screening in the initial phase of the program. The ball-plate tester eliminated the use of test bearings in the initial material screening phase where the important factor was to evaluate the lubricants and bearing materials without the confounding effect of other bearing parameters. No tests were conducted in a nuclear radiation field; however, consideration was given to such an environment in the selection of the candidate materials. The lubricant investigation described herein resulted in the selection of four materials, bronze-filled fluorocarbon, bronze-filled polyimide, Ag-WSe<sub>2</sub>-polyimide and Ag-MoS<sub>2</sub>, for further evaluation in actual bearing tests. These materials show promise of providing a significant increase in bearing life when operating in a liquid hydrogen environment. (Author)

**A66-12259****A NEW SYNTHETIC HYDROCARBON LUBRICANT FOR EXTREME-TEMPERATURE APPLICATIONS.**

I. N. Duling, J. Q. Griffith, and R. S. Stearns (Sun Oil Co., Research and Development Div., Marcus Hook, Pa.).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-1, 11 p. 32 refs.

Polyolefin fluids covering a wide viscosity range have been produced in quantities sufficient for direct comparison with petroleum oils and with existing synthetic-lubricants. Preliminary studies, conducted to choose the best synthesis route, revealed that hydrogenated oligomers of octene-1 offered the optimum balance of high viscosity index, low pour point, and excellent stability. Further work with alpha-olefin blends, aimed at the most economical approach, now shows that essentially equivalent results can be obtained with the proper blend of C<sub>6</sub> to C<sub>10</sub> olefins. Such fluids when produced in large volumes could compete economically with present synthetics. Tests on two candidate products - an automatic transmission fluid for high-temperature service and a jet engine lubricant - demonstrate product capabilities under conditions which cannot be satisfied with conventional petroleum oils. (Author)

**A66-12261****METHYL ALKYL SILICONES - A NEW CLASS OF LUBRICANTS.**

E. D. Brown, Jr. (General Electric Co., Silicone Products Dept., Waterford, N.Y.).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-4, 6 p. 7 refs.

A new family of lubricants, hybrids between silicones and hydrocarbons, is introduced and characterized. The physical properties of representative members of the series are presented and their exceptional lubricating ability is shown. A possible mechanism for such lubricity is postulated. (Author)

**A66-12298****EVALUATION OF CORROSION CONTROL ON AIRCRAFT SKIN COUNTERSINKS AND FASTENERS.**

A. R. Erben (McDonnell Aircraft Corp., St. Louis, Mo.).

(National Association of Corrosion Engineers, Annual Conference, 20th, Chicago, Ill., Mar. 9-13, 1964, Paper.)  
Materials Protection, vol. 4, Aug. 1965, p. 18-22.

Description of an investigation to determine best method and material for preventing corrosion in countersink areas of fasteners

## A66-12299

on aircraft skin. Methods evaluated include sealant type coatings, chemical treatments, mechanical barriers, platings on fasteners, and organic coatings on fastener heads. Test was as follows: two hours at 250°F (121°C) before load cycling at -65°F (-54°C) for each chemical and sealant type barrier material, then all materials were subjected to load cycling at the low temperature. Thereafter specimens were exposed to 675 hours of salt spray, followed by visual and metallographic examination. Evaluations showed zinc chromate primer, two sealant materials, and epoxy primer on fastener head to be best materials of those tested. (Author)

### A66-12299

#### STRESS CORROSION OF SOME AIRCRAFT MATERIALS AT HIGH TEMPERATURE.

George Martin (North American Aviation, Inc., Los Angeles, Calif.). (National Association of Corrosion Engineers, Annual Conference, 20th, Chicago, Ill., Mar. 9-13, 1964, Paper.)

Materials Protection, vol. 4, Aug. 1965, p. 23, 24, 26.

Discussion of the results of a 15,000-hour test with two titanium alloys, two precipitation hardening steels, and two superalloys exposed at 650°F (343°C). Specimens of the test materials were stressed at 23 to 90% of yield. Surface treatments of the specimens were salt coatings, braze coating, and salt coated braze coating. Stress corrosion characteristics and mechanical and metallurgical property changes are discussed. (Author)

### A66-12300

#### CORROSION AND THE WHIRLYBIRDS.

A. S. Falcone (Kaman Aircraft Corp., Bloomfield, Conn.). (National Association of Corrosion Engineers, Annual Conference, 20th, Chicago, Ill., Mar. 9-13, 1964, Paper.)

Materials Protection, vol. 4, Aug. 1965, p. 27, 28, 30, 31.

Discussion of corrosion problems encountered in application of protective treatments on helicopters. The author also discusses causes of corrosion attack on various components such as transmission gears and rotor blades; he emphasizes that proper design could have eliminated some corrosion problems. The materials engineering specialist is required by policy in design stage of helicopter manufacturing to specify on blueprints those features necessary to prevent corrosion. (Author)

### A66-12317

#### EXPLOSION CLAD PLATE FOR CORROSION SERVICE.

Andrew Pocalyko (Du Pont de Nemours and Co., Inc., Explosives Dept., Pompton Lakes, N.J.).

(National Association of Corrosion Engineers, South Central Region Conference, Dallas, Tex., Oct. 20-22, 1964, Paper.)

Materials Protection, vol. 4, June 1965, p. 10-15. 21 refs.

Explosion cladding is a joining process in which energy of detonating explosives is controlled so that similar and dissimilar metals are metallurgically bonded, without intermediate metal and without externally applied heat. The author (1) explains advantages of this bonding method, (2) discusses metallurgical bond achieved and properties of clad products including corrosion resistance, and (3) briefly discusses several applications using clad plate. (Author)

### A66-12318

#### EDGE CORROSION ON AIRCRAFT - EXPERIMENTING WITH ALUMINUM, MAGNESIUM, AND STEEL.

S. L. Chisholm (U.S. Navy, Naval Air Station, San Diego, Calif.). (National Association of Corrosion Engineers, Western Region Conference, Anaheim, Calif., Sept. 25-27, 1963, Paper.)

Materials Protection, vol. 4, Apr. 1965, p. 48-50.

Discussion of experiments to determine causes and methods for prevention of metallic edge corrosion of naval aircraft. Metals tested were carbon steel, 7075T6 aluminum, and AZ31B magnesium. The primary purpose of the experiments was to evaluate surface treatments, primers, and performance of epoxy enamels as compared to acrylic-nitro-cellulose lacquer systems. (Author)

### A66-12371

#### DIFFUSED ALUMINUM COATINGS FOR HIGH TEMPERATURE SERVICE.

Robert S. Brown (Union Carbide Corp., Stellite Div., New Products Dept., Kokomo, Ind.).

(National Association of Corrosion Engineers, North Central Region Conference, Minneapolis, Minn., Sept. 28-30, 1964, Paper.)

Materials Protection, vol. 4, July 1965, p. 50, 51.

Brief description of the performance of diffused aluminum coatings in high temperature applications. The method of applying diffused aluminum to several different base alloys is outlined, and an oxidation test is described and certain of its results are tabulated. The equipment required for application is discussed, and the reactions occurring during the coating process are examined. B. B.

### A66-12723 #

#### STUDY OF Al-Zn-Mg ALLOYS. II.

Takuichi Morinaga, Tsuneo Takahashi, and Junichiro Yamashita (Tokyo Institute of Technology, Tokyo, Japan).

Light Metals (Tokyo), vol. 15, Sept. 1965, p. 280-286. 6 refs.

In Japanese.

Study of the effects of Cr and Mn on the aging mechanism and anticorrosion properties of Al-Zn-Mg permanent mold-casting alloys with the following compositions: 4% Zn and 2% Mg; 4% Zn, 2% Mg, and 0.3% Cr; and 4% Zn, 2% Mg, 0.3% Cr, and 0.5% Mn. In experiments on natural aging at room temperature the hardness is found to approach an approximately stable state from about the 21st day after casting and to be slightly improved in comparison with ordinary alloys by the addition of Cr and (Cr + Mn). A. B. K.

### A66-13059 #

#### STRESS CORROSION AND TITANIUM ALLOY DESIGN FOR HIGH TEMPERATURE APPLICATIONS.

H. Rosenberg, H. Cox, and E. Erbin (Titanium Metals Corporation of America, West Caldwell, N.J.).

American Institute of Aeronautics and Astronautics, Royal Aeronautical Society, and Japan Society for Aeronautical and Space Sciences, Aircraft Design and Technology Meeting, Los Angeles, Calif., Nov. 15-18, 1965, Paper 65-764. 12 p.

Members, \$0.50; nonmembers, \$1.00.

Investigation of stress corrosion cracking (hot-salt stress corrosion) in titanium alloys in the presence of salt (chloride), elevated temperatures, and sustained stress. The time-temperature-stress parameters are examined, and attempts are made to discover and apply to new alloys the basic mechanisms at work. The peculiarity of the fact that corrosion has been observed to occur at temperatures as low as 525°F is pointed out. Data concerning the threshold stresses of 5 commercial titanium alloys, and the limiting stresses for cracking at 800°F vs design properties, are presented. Based on the 525°F threshold temperature - which was the same for all alloys - the basic conclusion is drawn that no known metallurgical reaction is responsible, but rather an external factor. It is concluded that cracking is due to an external reaction between salt and water which produces HCl, and that the latter attacks the alloys; also that a vapor phase, rather than an electrochemical reaction, is involved. Grain boundaries and the propagation of cracking along them are discussed. Improved alloys are expected to result from the investigation. M. L.

### A66-13221 #

#### FUELS AND LUBRICANTS FOR THE NEXT GENERATION AIRCRAFT - THE SUPERSONIC TRANSPORT.

W. G. Dukek (Esso Research and Engineering Co., Linden, N.J.).

(Esso Air World, vol. 17, Mar.-Apr. 1965, p. 119-125; Institute of Petroleum, Meeting, London, England, May 20, 1964, Paper.)

Esso Air World, vol. 18, July-Aug. 1965, p. 7-12. 8 refs.

[For abstract see Accession no. A65-27161 16-27]

### A66-13374

#### THE BEHAVIOR OF MATERIALS IN CORROSIVE ENVIRONMENTS.

W. C. Herron (Lockheed Aircraft Corp., Lockheed-Georgia Co., Materials Sciences Laboratory, Marietta, Ga.).

Industrial Research, vol. 7, Nov. 1965, p. 76-82.

Discussion of the effects of corrosive environments and corrosion on various metals and a description of several anticorrosion techniques which are applicable to protecting the surfaces of such

metals. Any environment containing moisture or oxygen can be thought of as being corrosive to metals. The principal factors involved in corrosion are (1) two areas of different potential, (2) an internal electrical path, and (3) an external electrolyte. Variations in composition, temperature, stress, oxygen concentration, and many other conditions may cause a difference in potential. In order to inhibit corrosion, the circuit between two dissimilar areas must be broken by the use of barrier materials such as - in a simple case - paint. It is noted that anodic coatings are very effective on aluminum. Magnesium has a high resistance to alkalis but is susceptible to attack by acids. It requires a special oxidizing treatment followed by an organic sealant.

D.P.F.

**A66-13398****THE EFFECTS OF REACTOR RADIATION ON THREE HIGH-TEMPERATURE SOLID-FILM LUBRICANTS.**

R. H. McDaniel (General Dynamics Corp., General Dynamics/Fort Worth, Nuclear Aerospace Research Facility, Fort Worth, Tex.). (American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-6, 1965, Preprint 65AM 5C1.)

*Lubrication Engineering*, vol. 21, Nov. 1965, p. 463-471; Discussion, H. E. Sliney (NASA, Lewis Research Center, Cleveland, Ohio), Mel Lavik (Midwest Research Institute, Kansas City, Mo.), p. 472; Author's Closure, p. 473. 11 refs. Contract No. AF 29(601)-6213.

[For abstract see issue 14, page 2034, Accession no. A65-24248]

**A66-13834****FRICION AND WEAR.**

I. V. Kragelskii (Academy of Sciences, Institute of Mechanical Engineering, Laboratory of Friction and Friction Materials, Moscow, USSR).

Washington, D.C., Butterworth, Inc., 1965. 346 p. Translation. \$16.50.

The main purpose of this book is to present a general picture of the nature of the interaction between solid surfaces, to establish general concepts in this relatively new field of science, and finally to demonstrate the possibility, in some cases, of making engineering and design calculations. A general description of the process is given. Three successive phases are considered: interaction between the surfaces, the changes occurring in the surface layer, and the various ways in which the surfaces are changed. The concept of a frictional junction is introduced; a classification is given of types of frictional junctions, and definitions of friction and wear are proposed. The contact of real surfaces and the extent to which they approach each other are studied. Three types of contact are investigated: elastic, plastic, and contacts involving work hardening. Expressions are given to determine the contact area and the approach of the surfaces in terms of the load, surface roughness, and the mechanical properties of the materials. The basic mathematical expressions required to determine the temperature rise produced during sliding is given. Various temperature problems arising during friction are investigated, and examples of temperature calculations are given. Transition criteria of two types are considered. The first corresponds to the transition from elastic to plastic deformation, the second from plastic displacement to cutting. The analysis of the wear process is dealt with. It is shown that various forms of wear can occur: microcutting, plastic displacement of a surface layer, elastic deformation of interlocked material, and destruction of surface films. Mathematical expressions for each form are given. An analysis of the friction process is given and it is shown that friction is of a composite nature. Various types of resistance are considered, including elastic displacement of material, plastic displacement, cutting and destruction of surface films. An analysis of sliding friction is given. The rheological phenomena taking place at a frictional contact are described; a quantitative method is given for analyzing mechanical relaxation oscillations. Boundary friction and the way in which it is affected by various factors are considered. Some results are also given relating to lubricants and the mechanism of action of additives. A hydrodynamic theory of semifluid friction developed by Kudinov is given. A description of experimental methods used in friction and wear investigations is also given. Friction and antifricition materials are considered. A theory of friction and antifricition characteristics is given, together with some information on the main types of materials used.

M.F.

**A66-13933****MEASURING METALLIC CORROSION BY RADIATION BACKSCATTERING AND RADIATION INDUCED X-RAYS.**

Sigmund Berk (U.S. Army, Pitman-Dunn Institute for Research, Radioisotope Laboratory, Frankford Arsenal, Philadelphia, Pa.). (American Nuclear Society and Atomic Industrial Forum, Joint Meeting and Atom Fair, San Francisco, Calif., Nov. 30-Dec. 3, 1964, Paper.)

*Materials Protection*, vol. 4, Nov. 1965, p. 39-41. 10 refs.

Description of a nondestructive method of measuring metallic corrosion in which a Pm-147 beta-backscattering device is used to determine the relative amount of corrosion on several metallic specimens. It is concluded that the method is effective in measuring the extent of oxidation or corrosion of nickel, niobium, and tantalum. A brief description is also given of a beta-particle induced X-ray method for measuring corrosion of copper, steel, and brass.

M. L.

**A66-14156 #****SOME PROBLEMS IN THE THEORY OF GAS LUBRICATION WITH ALLOWANCE FOR TEMPERATURE VARIATIONS (NEKOTORYE ZADACHI TEORII GAZOVOI SMAZKI S UCHETOM TEMPERATURNYKH IZMENENII).**

I. I. Shidlovskaya.

*Inzhenernyi Zhurnal*, vol. 5, no. 5, 1965, p. 958-967. 5 refs. In Russian.

Derivation of the equations of gas-lubricated bearings, valid over a wide range of temperatures and Mach numbers. Also derived is an equation for determining the pressures in steady-state lubrication, at small Mach numbers. The solutions of this equation are analyzed for lubricant layers between plane surfaces the temperatures of which can differ without bound.

V.P.

**A66-14240 #****POSSIBLE ROLE OF COMPRESSIONAL VISCOELASTICITY IN CONCENTRATED CONTACT LUBRICATION.**

R. S. Fein (Texaco, Inc., Research Center, Beacon, N.Y.). (American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper 65 - Lub-4. 5 p. 17 refs. Members, \$0.50; nonmembers, \$1.00.

An equation relating liquid density and viscosity under transient pressure conditions is derived. The derivation combines approximate phenomenological descriptions of the viscoelastic compression of a liquid and the dependence of viscosity on pressure and density. Solutions of the equation for a "step"-pressure increase and a semielliptical pressure cycle show that density and viscosity of Newtonian lubricants may significantly lag pressure transients under concentrated-contact lubrication conditions. Qualitatively, the lag effects appear to account at least partially for anomalous experimental observations involving asperity interactions and elastohydrodynamic lubrication of rollers.

(Author)

**A66-14241 #****FRICION-INDUCED VIBRATION.**

C. A. Brockley (British Columbia, University, Dept. of Mechanical Engineering, Vancouver, Canada), R. Cameron (Cambridge, University, Cambridge, England), and A. F. Potter (Honeywell Controls, Ltd., Aeronautical Div., Minneapolis, Minn.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper 65 - Lub-5. 7 p. 12 refs. Members, \$0.50; nonmembers, \$1.00.

National Research Council Grant No. A1065.

Friction-induced vibration has been studied in a system consisting of an elastically suspended, damped slider which is loaded against a surface moving at a constant velocity. Exact analysis reveals a critical velocity which limits the incidence of vibration. The critical velocity depends on damping, load, stiffness, and friction characteristics which vary with time and velocity. Approximations in the theory yield an amplitude-velocity equation and another critical velocity relationship. Reasonable agreement is found to exist between the exact and approximate theories for critical velocity. Experimental results for several systems illustrate amplitude-velocity relationships and the existence of critical velocities. The correlation between the experimental

## A66-14244

results and the approximate theory indicates that the analytical method could be used to predict the vibration behavior of actual systems. (Author)

### A66-14244 #

#### A THEORY OF LUBRICATION BY MICROIRREGULARITIES.

D. B. Hamilton, J. A. Walowit, and C. M. Allen (Battelle Memorial Institute, Columbus, Ohio).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper 65 - Lub-11. 9 p. 10 refs. Members, \$0.50; nonmembers, \$1.00.

Description of a theory of liquid lubrication applicable to parallel surfaces, such as the surfaces of a rotary-shaft face seal. The lubrication mechanism presented is based on surface micro-irregularities and associated film cavities. Closed-form analytical solutions are obtained giving load capacity as a function of speed, viscosity, and surface-asperity dimensions. The theoretical results agree qualitatively with load capacity determined experimentally for three asperity distributions. (Author)

### A66-14247 #

#### A CORRELATION OF THE FRICTIONAL AND VISCOELASTIC PROPERTIES OF PLASTICS AND RUBBER.

K. C. Ludema (Michigan, University, Ann Arbor, Mich.) and D. Tabor (Cambridge, University, Cavendish Laboratory, Cambridge, England).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper 65 - Lub-15. 9 p. 13 refs. Members, \$0.50; nonmembers, \$1.00.

Demonstration that variations in the coefficient of sliding friction of rubber and plastics by amounts ranging from 200 to 800% with variations in sliding speed and temperature are related to the viscoelastic properties of the plastics and rubbers. A model of the friction mechanism in rubber is presented. In this model it is assumed that for a particular sliding speed the strain rate in the adhesion bonds is much higher than the strain rate in the substrate. Thus, in the equation for friction force,  $F = AS$ , the strain rate that controls the shear strength,  $S$ , of the adhesion bonds is much greater than the strain rate that controls the area of contact,  $A$ . A correlation with rubber using values of  $A$  and  $S$  derived from published data shows a variation in  $F$  that closely approximates experimental results for  $F$ . No correlation was made for plastics, but friction data for six plastics are presented, showing large variations in friction with variations in sliding speed and temperature. (Author)

### A66-14249 #

#### ANALYSIS OF TURBULENT LUBRICATION USING PRANDTL'S MIXING-LENGTH THEORY.

Elmer L. Wheeler (Garrett Corp., AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.).

American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper 65 - Lub-17. 11 p. 10 refs. Members, \$0.50; nonmembers, \$1.00.

AEC-supported research.

Following the methods proposed by Constantinescu (1959), a solution has been developed for predicting the performance of journal bearings operating in the turbulent regime. The factor defining the magnitude of the mixing length has been determined in a manner that appears to be free from the effects of Reynolds number and bearing geometry. Numerical solutions for pressures, friction, and load are compared with experimental data, and calculated load data for turbulent bearing operation are presented in the form of a dimensionless design curve. (Author)

### A66-14933

#### BRITTLE AND PLASTIC BEHAVIOR OF HOT-PRESSED BeO.

G. G. Bente and R. M. Kniefel (North American Aviation, Inc., Atomics International Div., Canoga Park, Calif.).  
(American Ceramic Society, Annual Meeting, 66th, Chicago, Ill., Apr. 22, 1964, Paper.)

American Ceramic Society, Journal, vol. 48, Nov. 21, 1965, p. 570-577. 26 refs.

AEC Contract No. AT (11-1)-GEN-8.

The flow and fracture mechanisms of well-characterized hot-pressed polycrystalline BeO were studied. Modulus of rupture tests were made from -196 to 1800°C on specimens of constant density and varying grain size. The fracture surfaces were studied with fractography and X-ray rocking curves. Compression tests were performed both below and above the phase transformation temperature for BeO (2050°C). A model was developed for fracture below 1000°C, involving propagation of existing surface cracks through dissimilar barriers to form a crack front of irregular shape which generates dislocations near the tip. Above 1000°C a model of grain boundary sliding to open cracks at grain boundary junctions was indicated. Permanent deformation under compression was attributed to grain separation and void formation. (Author)

### A66-15526 #

#### HYDRODYNAMIC LUBRICATION OF PARTIAL POROUS METAL BEARINGS.

C. A. Rhodes (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and W. T. Rouleau (Carnegie Institute of Technology, Dept. of Mechanical Engineering, Pittsburgh, Pa.).  
American Society of Mechanical Engineers, Winter Annual Meeting, Chicago, Ill., Nov. 7-11, 1965, Paper 65 - WA/Lub-3. 8 p. 10 refs. Members, \$0.75; nonmembers, \$1.50.

Partial porous metal bearings are analyzed to determine their performance during steady-state operating conditions with a full film of lubricant. The pressure distribution is determined by a simultaneous solution of the two-dimensional Reynolds equation in the film region and the Laplace equation within the porous bearing material. An infinite-series solution is obtained for pressure utilizing the Galerkin method to determine coefficients. Numerical values of load capacity and coefficient of friction are presented for bearing arcs of 180, 150, and 120°. (Author)

### A66-15544 #

#### STATUS REPORT ON THEORY AND EXPERIMENTS ON HEAT PIPES AT LOS ALAMOS.

T. P. Cotter, J. Deverall, G. F. Erickson, G. M. Grover, E. S. Keddy, J. E. Kemme, and E. W. Salmi.

IN: EUROPEAN NUCLEAR ENERGY AGENCY AND INSTITUTION OF ELECTRICAL ENGINEERS, INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, LONDON, ENGLAND, SEPTEMBER 20-25, 1965. [A66-15532 05-03] 1965. 12 p. 8 refs.

Survey of experiments performed on the characteristics of heat pipes. The status of corrosion studies at elevated temperatures is reviewed. A quantitative engineering theory for the design and performance analysis of heat pipes is described. The experimental investigations were divided into three temperature regimes which reflect the application areas of interest. The lowest temperature regime is of little concern for thermionic applications. Water and the alcohols are used as working fluids, and control of satellite component temperatures is one objective. The next temperature regime is from 700 to 1400°K for heat removal from the collectors of thermionic converters. While the heat transfer rates are not excessive in most applications, the lifetime requirement is long. Therefore, life testing of suitable material combinations is of importance. The high-temperature regime of 1400 to 2100°K presents the most challenging area of heat pipe application. Test heat pipe sizes ranged from 1 to 2 cm in diameter and from 10 to 43 cm in length. The capillary structure was formed from 100-mesh screen with 0.003-in. -diam wire. Lithium is an ideal heat pipe fluid because of its high latent heat of vaporization and its high surface tension. Tantalum and tantalum alloys are used as heat pipe container tubes at temperatures above 1500°C. Examination of a sectional heat pipe after operation with silver for 100 hr at 1900°C was made. The total mass of silver circulated during this period was 200 kg. Estimates based on three pipes operated at 1900°C gave mass transport rates between 2 and 4 x 10<sup>-9</sup> grams per joule of heat transferred. These rates indicate a tantalum solubility in silver of the order of 10 ppm. M.M.

### A66-15622 #

#### LUBRICANT EFFECTS ON FATIGUE IN A STATIONARY CONCENTRATED CONTACT UNDER VIBRATORY LOADING.

R. A. Burton and J. A. Russell (Southwest Research Institute, San Antonio, Tex.).  
American Society of Mechanical Engineers, Winter Annual Meeting, Chicago, Ill., Nov. 7-11, 1965, Paper 65-WA/CF-3, 8 p. 11 refs.  
 Members, \$0.75; nonmembers, \$1.50.  
 Contract No. N0W-64-0460-d.

Contact fatigue, brinelling, and erosion are reported, for a stationary ball-on-flat contact, subjected to oscillatory normal load. Damage was least in the absence of lubricant, and greatest with a diester lubricant. Low-viscosity mineral oil was less severe in its effects than was a high-viscosity mineral oil. In those cases where damage was least, it could be attributed to a process of fatigue spalling. In those cases where it was severe, other processes such as fretting could be postulated, but fatigue still appeared to be the favored cause. (Author)

#### A66-15624 #

CORRELATION OF THE PITTING FATIGUE LIFE OF BEARINGS WITH ROLLING CONTACT RIG DATA.

JoDean Morrow (Illinois, University, Urbana, Ill.).  
American Society of Mechanical Engineers, Winter Annual Meeting, Chicago, Ill., Nov. 7-11, 1965, Paper 65-WA/CF-5, 4 p. 6 refs.  
 Members, \$0.75; nonmembers, \$1.50.

The general method for correlating the fatigue pitting life of simple rolling elements with the life of bearings is discussed. A "correlation equation" is presented which permits the pitting fatigue life of full-scale bearings to be estimated from minimal rolling contact rig data. Three M-50 (MV-1) bearings are analyzed using this equation. In all three cases the life is predicted within a factor of two. (Author)

#### A66-15849 #

HEMISPHERICAL TOTAL-EMITTANCE MEASUREMENT IN THE TEMPERATURE RANGE 175 TO 350°K FOR SELECTED THERMAL-CONTROL AND CORROSION-PROTECTION COATINGS.

W. D. Wood and C. L. Coffin (Battelle Memorial Institute, Columbus, Ohio).

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-18, 12 p. 10 refs.

Members, \$0.50; nonmembers, \$1.00.

Thermal analyses of the guidance system and support equipment located in the Saturn IB/V Vehicle Instrument Unit indicated that a hemispherical total emittance in the range 0.1 to 0.4 would serve to minimize stabilized-platform temperature excursions and to maximize peripheral electronic-component life in the event of coolant-system failure. These findings prompted a study, which was conducted by the Battelle-Columbus Laboratories for NASA, MSFC, to measure surface emittance of a number of electrochemical and paint coatings on 6061 T-6 aluminum, Type QMV beryllium, and Type AZ-91-CP6 magnesium in the temperature range 175 to 350°K. Emittance was measured by a transient calorimetric technique wherein an emittance specimen is suspended inside a blackened, cold-walled, vacuum chamber and allowed to cool by radiation to the cold, absorbing chamber walls. In addition to emittance, effects of surface and substrate roughness and coating thickness on hemispherical total emittance were investigated, and emittance variations resulting from surface fingerprints were assessed. This paper presents measured emittance values for the coatings and temperature range selected and discusses their significance. Also included are descriptions of emittance-measurement apparatus and procedures, with details of emittance-specimen surface preparation. (Author)

#### A66-15937 #

VAPOR DEPOSITED GOLD THIN FILMS AS LUBRICANTS IN VACUUM (10<sup>-11</sup> mm Hg).

T. Spalvins and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).

American Vacuum Society, Annual Vacuum Symposium, 12th, New York, N.Y., Sept. 29-Oct. 1, 1965, Paper, 21 p. 17 refs.

Gold thin films of 1800 Å to be used as lubricants were vapor-deposited on Ni, Ni-Cr, and Ni-Re substrates. Strong bonding (adhesion) and durability between the film and substrate were found to be essential when thin films are used as a lubricant. Factors which were investigated included the selection of the film and substrate material. Strong durability of the thin film is directly

related to the type and structure of the interfacial region. Two methods of substrate preparation prior to vapor deposition were investigated: (1) mechanically polished surface and (2) electron bombarded surface. Gold was vapor-deposited on the mechanically polished surface at room temperature and on the thermally etched surface at an elevated temperature approximately (800°F). Strength and durability of the films were investigated in sliding friction experiments with a hemispherical niobium rider sliding on the films at a velocity of 5 ft/min. Results obtained in these friction experiments indicated that the film endurance life was considerably better on the thermally etched surface. This increased film durability with the thermally etched surface is believed to be due to the formation of a diffusion-type interface between the film and the substrate. Due to the disregistry at grain boundaries, a higher rate of diffusion and preferential trapping in and around the grain boundaries occurs, with these regions acting as "lubricant reservoirs" during the friction experiments. (Author)

#### A66-16071 #

CORROSION OF REFRACTORY ALLOYS BY REFLUXING POTASSIUM.

C. M. Scheuermann (NASA, Lewis Research Center, Cleveland, Ohio).

American Institute of Mining, Metallurgical and Petroleum Engineers, Symposium on Refractory Metals, 4th, French Lick, Ind., Oct. 3-5, 1965, Paper, 17 p. 9 refs.

Outline of a corrosion capsule study for testing the resistance of columbium- and tantalum-base tubing alloys to refluxing potassium over the temperature range of 1800 to 2400°F, and for times up to 4000 hr. A proposed mechanism, for the corrosion of columbium metal and alloys by refluxing potassium, is discussed. The mechanism is described for both gettered and ungettered alloys. It is concluded that the ungettered refractory metal alloys are more rapidly and drastically attacked by refluxing potassium than are the gettered alloys. B.B.

#### A66-16136

THE FRICTIONAL BEHAVIOR OF MATERIALS IN JP-4 FLUID.

R. H. Krueger (Borg-Warner Corp., Roy C. Ingersoll Research Center, Des Plaines, Ill.).

Lubrication Engineering, vol. 21, Dec. 1965, p. 501-505. 6 refs.

A laboratory apparatus was used to measure friction of materials sliding in JP-4 fluid in order to predict the performance of a particular type of hydraulic pump. Only cemented tungsten carbide gave low friction. Lowest coefficients of friction were obtained with cermet containing uniform rounded tungsten carbide particles, 3 to 16% cobalt, and no apparent oxides or voids. Friction increased with increasing surface roughness of tungsten carbide. Repetitive testing of different tungsten carbide materials did not significantly change coefficient of friction in JP-4 at 300°F. Metal-PTFE compacted materials gave low friction in JP-4 but were not satisfactory because of a small amount of wear. (Author)

#### A66-16486 #

METHOD FOR DETERMINING THE SERVICE LIFE OF ANTI-FRICTION BEARINGS FROM TEST RESULTS.

András Horváth (Hungarian Antifriction Bearing Factories, Technological Section, Budapest, Hungary).

IN: HUNGARIAN ACADEMY OF SCIENCES, PROCEEDINGS OF THE CONFERENCE ON DIMENSIONING AND STRENGTH CALCULATIONS, 2ND, BUDAPEST, HUNGARY, OCTOBER 5-10, 1965, [A66-16472 06-32]

Edited by L. Kisbocskói.

Budapest, Akadémiai Kiadó, 1965, p. 303-312.

The service life of antifriction bearings is represented by the Weibull distribution law. Neither parameter of the distribution law is constant, but is to be calculated from test results. This discussion has introduced a method for computing the parameters of the distribution law, and deducted the density function of the Weibull distribution law which gives information about the frequency of the service life values varying within a wide range. (Author)

**A66-16608 =**

EFFECT OF ALUMINUM ADDITIONS ON THE CORROSION RESISTANCE OF TITANIUM IN SOLUTIONS OF ACETIC AND NITRIC ACIDS [VLIVANIE LEGIROVANIA ALIUMINIEM NA KORROZION-NUIU STOIKOST' TITANA V RASTVORAKH UKSUSNOI I AZOTNOI KISLOT].

G. M. Kirkin and N. P. Zhuk.

Zashchita Metallov, vol. 1, Nov.-Dec. 1965, p. 648-651. 6 refs. In Russian.

Investigation of the corrosion resistance of titanium and its alloys with 0.1, 0.3, 0.6, 1.0, 3.0, and 5.0% Al in 5 to 80% acetic acid and 5 to 56% nitric acid at temperatures from 25 to 80°C. The high corrosion resistance of the samples, the high positive values of the stationary electrode potentials, and the absence of an active region on the anodic polarization curve indicate the passive state characteristic of these alloys under the experimental conditions. Aluminum additions are found to slightly reduce the corrosion resistance. V. Z.

**A66-16690**

THE EFFECT OF HEAT TREATMENT ON THE PROPERTIES OF POROUS STAINLESS STEEL.

S. M. Solonin and L. V. Globa (Akademiia Nauk Ukrainsoi SSR, Institut Problem Materialovedeniia, Kiev, Ukrainian SSR).

(Poroshkovaia Metallurgiiia, Jan. 1965, p. 13-19.)

Soviet Powder Metallurgy and Metal Ceramics, Jan. 1965, p. 9-13. 7 refs. Translation.

Study concerning experiments which show that the structural factor exerts a marked influence on the properties of porous stainless steel. It is noted that accelerated cooling of ferritic-martensitic steel, Kh17N2, and ferritic steel, Kh30, after sintering, combined with additional heat treatment, produces a substantial increase of strength and corrosion resistance compared with the industrial heat treatment process employed for these steels (slow cooling with the muffle after sintering). Accelerated cooling of these steels from the sintering temperature also markedly increases their strength and corrosion resistance. It has been established that, unlike cast stainless steels, which soften after homogenizing, porous sintered austenitic steels, 0Kh18N9 and Kh23N18, show a significant strength increase after such heat treatment. It is pointed out that accelerated cooling from the sintering temperature substantially increases the strength and corrosion resistance of austenitic steels, 0Kh18N9 and Kh23N18, compared with slow cooling with the muffle after sintering. M. F.

**A66-16801**

STRESS CORROSION CRACKING OF MARAGING STEEL.

R. B. Setterlund (Bechtel Corp., Refinery and Chemical Div., San Francisco, Calif.).

(National Association of Corrosion Engineers, Annual Conference, 20th, Chicago, Ill., Mar. 9-13, 1964, Paper.)

Materials Protection, vol. 4, Dec. 1965, p. 27-29; Discussion, E. H. Phelps (U. S. Steel Corp., Applied Research Laboratory, Monroeville, Pa.), J. F. Mason (International Nickel Co., New York, N. Y.), J. R. Daesen, and P. D. Hedgecock, p. 29; Author's Reply, p. 29.

Contract No. DA-04-495-ORD-3069.

Comparison of the fracture toughness and stress corrosion resistance of several heats of maraging steel with results for low-alloy and hot-work die steel. Environmental stress corrosion tests were conducted in distilled, tap, salt, and inhibited water solutions as well as in trichloroethylene, preservative oil, and natural sea-coast and laboratory atmospheres. It is concluded that the 18%-nickel grades of maraging steel possess high strength and toughness coupled with ease of welding and heat treatment. These properties make possible the construction of large-diameter rocket chambers of extremely high strength-to-weight ratios. It is noted, however, that despite its high toughness, maraging steel will fail in a brittle manner when stressed and exposed to corrosive aqueous solutions, such as distilled water, tap water, or salt water. M. M.

**A66-17491**

FUNGAL AND CORROSION RESISTANCE OF SEVERAL INTEGRAL TANK LINING MATERIALS.

G. F. Hazzard and E. G. Kuster (Department of Supply, Defence Standards Laboratories, Maribyrnong, Victoria, Australia). (Royal Aeronautical Society, Lecture, Melbourne, Australia, July 18, 1963.)

Royal Aeronautical Society, Journal, vol. 69, Dec. 1965, p. 869-875. 6 refs.

Experimental investigation of the fungus and corrosion resistance of various coatings for integral aircraft fuel tanks. Some of the conclusions drawn from the results of laboratory tests of basic film properties are: (1) both the polyurethane and the epoxy materials are markedly superior in resisting fungi to either the nitrile or polysulfide rubber materials; (2) incorporation of fungicides in nitrile rubber films does not appear to confer adequate resistance to fungus penetration; (3) the polyurethane films show very low moisture retention values and greater resistance to the passage of water through them than do the nitrile or polysulfide rubber films; and (4) the two-part polyurethane films tested showed rapid breakdown in resistivity, and permitted visible corrosion in a very short time in immersion tests in which nitrile rubber provided protection, in the absence of fungus contamination, for over 200 days. M. M.

**A66-18284**

FLUORIDE SOLID LUBRICANTS FOR EXTREME TEMPERATURES AND CORROSIVE ENVIRONMENTS.

Harold E. Sliney, Thomas N. Strom, and Gordon P. Allen (NASA, Lewis Research Center, Cleveland, Ohio).

(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 5C5.)

ASLE Transactions, vol. 8, Oct. 1965, p. 307-318; Discussion, C. D. Stuber (USAF, Wright Patterson Air Development Center, Dayton, Ohio), J. A. Nelson (Illinois, University, Dept. of Ceramic Engineering, Urbana, Ill.), and E. S. Bober (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.), p. 319-321; Authors' Closure, p. 321, 322. 11 refs.

[For abstract see issue 14, page 2034, Accession no. A65-24249]

**A66-18289**

ON THE DETERMINATION OF FRICTION FORCES IN TURBULENT LUBRICATION.

V. N. Constantinescu (Rumanian Academy, Institute of Applied Mechanics, Hydrodynamic Lubrication Laboratory; Bucharest Polytechnic Institute, Bucharest, Rumania) and S. Galetuse (Bucharest, Polytechnic Institut, Bucharest, Rumania).

(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 3A1.)

ASLE Transactions, vol. 8, Oct. 1965, p. 367-378; Discussion, Edward Saibel (Rensselaer Polytechnic Institute, Troy, N. Y.) and C. H. T. Pan (Mechanical Technology, Inc., Latham, N. Y.), p. 378, 379; Authors' Closure, p. 379, 380. 27 refs.

[For abstract see issue 14, page 2034, Accession no. A65-24252]

**A66-18291**

A REFINED SOLUTION TO THE THERMAL-ELASTOHYDRODYNAMIC LUBRICATION OF ROLLING AND SLIDING CYLINDERS.

H. S. Cheng (Mechanical Technology, Inc., Latham, N. Y.).

(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 4A2.)

ASLE Transactions, vol. 8, Oct. 1965, p. 397-407; Discussion, J. C. Bell and J. W. Kannel (Battelle Memorial Institute, Columbus, Ohio), p. 407-409; Author's Closure, p. 409, 410. 21 refs.

Navy-supported research.

[For abstract see issue 14, page 2035; Accession no. A65-24256]

**A66-18292**

LUBRICANT FILM THICKNESS AND WEAR IN ROLLING POINT CONTACT.

T. E. Tallian, J. I. McCool (SKF Industries, Inc., Engineering and Research Center, Research Laboratory, King of Prussia, Pa.),

E. F. Brady (Pennsylvania Military College, Chester, Pa.), and

L. B. Sibley (SKF Industries, Inc., Engineering and Research Center, Mechanical Test Section, King of Prussia, Pa.).

(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 4A4.)

ASLE Transactions, vol. 8, Oct. 1965, p. 411-424. 14 refs.

Contract No. NOW-61-0716-C.

[For abstract see issue 14, page 2034, Accession no. A65-24250]

**A66-18519 #****COMPLEX IONS AND STRESS-CORROSION CRACKING IN  $\alpha$ -BRASS.**

E. N. Pugh and A. R. C. Westwood (Martin Marietta Corp., Martin Co., Research Institute for Advanced Studies, Baltimore, Md.). *Philosophical Magazine*, 8th Series, vol. 13, Jan. 1966, p. 167-183. 18 refs.

Army-supported research.

A study has been made of the stress-corrosion cracking, rate of weight loss and surface condition of an alloy containing 70% copper and 30% zinc in 15N aqueous ammonia. The behavior is shown to be strongly dependent on the concentration of the cupric complex ion  $\text{Cu}(\text{NH}_3)_5^{2+}$  present in the environment. Stress-corrosion life decreased significantly with increasing complex-ion concentration, the relationship exhibiting a well-defined inflection at a critical concentration. Specimens immersed in solutions of concentrations exceeding the critical value were tarnished, while those exposed to less concentrated solutions appeared tarnish-free. These and other observations indicate that two mechanisms of stress corrosion cracking are operative, one in the presence of tarnish and the other in the absence of this layer. Possible mechanisms are discussed. A model has been developed to explain the dependence of the tarnishing reaction on the chemical composition of the environment.

(Author)

**A66-18761****THE ROLE OF DISLOCATIONS IN THE STRESS-CORROSION CRACKING OF 7075 ALUMINUM ALLOY.**

A. J. Jacobs (North American Aviation, Inc., Rocketdyne Div., Materials Research Dept., Canoga Park, Calif.). *ASM Transactions Quarterly*, vol. 58, Dec. 1965, p. 579-600. 8 refs.

NASA-supported research.

Dislocation structures in the 7075 forging alloy were studied by transmission electron microscopy and related to stress-corrosion cracking. It was possible to differentiate between a microstructure that is susceptible to stress-corrosion failure (T6) and one that is immune (T73). Various microstructures in 7075 alloy were correlated with their respective tendencies to stress-corrosion crack. The stress-corrosion prone structures contain networks of dislocations. Such networks are absent in the resistant condition. Because pitting proceeds identically in the T6 and the T73, viz., by the dissolution of large  $\text{MgZn}_2$  precipitate particles in the grain boundaries and grains, it is concluded that the critical role of the dislocations is to assist in the nucleation of cracks of appropriate geometry for propagation. A model is hypothesized to explain the course of stress-corrosion cracking in 7075-T6 and perhaps in other precipitation hardenable alloys as well.

(Author)

**A66-18838 #****SPARK IGNITER FOR HIGH-TEMPERATURE APPLICATIONS.**

Harold W. Wilson, Jr. (Union Carbide Corp., Research Institute, Tarrytown, N. Y.).

*Journal of Spacecraft and Rockets*, vol. 3, Jan. 1966, p. 160.

Account of the construction and testing of a new spark igniter that resists corrosive high-temperature environments. Unlike conventional spark plugs, this new spark igniter has operated successfully for more than 5 hr in  $\text{H}_2$ -CO- $\text{N}_2$ - $\text{O}_2$  fuel-rich and fuel-lean flames, at 50 to 120 psig chamber pressure and 2300 to 3000°K, without observable evidence of thermal shock or appreciable electrode erosion.

M. F.

**A66-19601****STRESS-CORROSION FAILURE.**

Peter R. Swann (United States Steel Corp., Edgar C. Bain Laboratory for Fundamental Research, Monroeville, Pa.). *Scientific American*, vol. 214, Feb. 1966, p. 72-81.

Examination of the phenomena related to stress-corrosion effects in metals. Surface energy and elastic energy are explained in terms of the relative energies possessed by surface atoms and atoms at the tip of a crack which have been displaced from their normal position by stress. Adsorption phenomena are discussed as an explanation for the fact that fractures can occur under very small stresses; the adsorbed ions lower the binding energy between surface atoms so that crack propagation can occur. The alternative pit and tunnel theory for explaining stress-corrosion is described. Transgranular fractures have been investigated by transmission electron microscopy. A method for directly observing the

chemical activity of slip steps is described. The mechanism by which a corrosion tunnel forms at an active slip step is investigated.

D. P. F.

**A66-19714**

REPORT OF SUBCOMMITTEE VIII ON FIVE-YEAR ATMOSPHERIC EXPOSURES OF MAGNESIUM PANEL-TYPE GALVANIC COUPLES. IN: AMERICAN SOCIETY FOR TESTING AND MATERIALS, ANNUAL MEETING, 68TH, PURDUE UNIVERSITY, LAFAYETTE, IND., JUNE 13-18, 1965, PROCEEDINGS. VOLUME 65. [A66-19713 08-17] Philadelphia, American Society for Testing and Materials, 1965, p. 172-181. 7 refs.

Discussion of a phase of a program to evaluate the galvanic corrosion caused by various dissimilar metals when coupled to magnesium alloys and exposed to different atmospheric conditions. The concern is with panel-type couples in which the galvanic effect of dissimilar metals could be evaluated through loss in tensile strength of the base panel when compared with similar uncoupled control panels exposed alongside of the coupled panels. The data presented were obtained on the third set of magnesium panel-type galvanic couples which were removed after five years' exposure at four different locations.

M. M.

**A66-19953****THE SUPER 12% Cr STEELS.**

J. Z. Briggs and T. D. Parker.

New York, Climax Molybdenum Co., 1965. 220 p.

A comprehensive literature survey of the Super 12% Cr family of steels, which find application in gas turbines and the aerospace industries, is offered. The effects of alloying elements are discussed, and various aspects of physical and mechanical properties of these steels are examined. A chapter is devoted to applications, and another to commercially produced grades and specifications. These steels can be heat-treated in large sections to tensile strengths over 200 ksi. Usable hot strengths at temperatures up to about 1200°F exceed those of other nonaustenitic steels, and compare favorably with those of austenitic steels in some ranges. Thermal stability is excellent. The steels have high hot ductility and resist embrittlement under stress. A damping capacity greater than that of austenitic steel, approaching that of the parent 12% Cr steel, is exhibited. The steels resist thermal shock and thermal fatigue, and have good corrosion resistance. They resist the effects of high-pressure hydrogen and stress-corrosion cracking, and are available in all forms. Processing and fabrication does not entail undue difficulties. An appendix contains over 1100 references classified according to subject.

F. R. L.

**A66-20156****LUBRICANTS FOR HIGH PERFORMANCE TURBINE ENGINES.**

Kenneth L. McHugh (Monsanto Chemical Co., St. Louis, Mo.). *Society of Automotive Engineers, Automotive Engineering Congress*, Detroit, Mich., Jan. 10-14, 1966, Paper 660071. 12 p. 22 refs. Members, \$0.75; nonmembers, \$1.00.

Description of the present status of aircraft turbine lubricant technology for high Mach number engines in general and SST's in particular. Performance capability criteria for aircraft lubricants are discussed in terms of stability, which includes autoignition temperature, degradation, coking, load carrying capacity, and toxicity characteristics. The advantages and disadvantages of the four basic types of lubricants are described. Graphs are given for the torque requirements in a gear box as a function of temperature and lubricant costs as a function of consumption and 0.1 drain frequency.

D. P. F.

**A66-20157 #****LUBRICANT REQUIREMENTS FOR HIGH TEMPERATURE BEARINGS.**

Richard P. Shevchenko (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.). *Society of Automotive Engineers, Automotive Engineering Congress*, Detroit, Mich., Jan. 10-14, 1966, Paper 660072. 15 p. Members, \$0.75; nonmembers, \$1.00.

Desirable lubricant properties for high-temperature bearings are discussed from the bearing application engineering standpoint. This discussion is preceded by a short description of a jet engine lubrication system. The need for more realistic overall engine



## A66-20158

lubrication-system lubricant screening tests is stressed. Recommendations are made for incorporation of a thrust bearing rolling contact fatigue tester, an engine simulator, and more exhaustive engine evaluation in lubricant specifications. The case history of the compromises and their justification in the selection of a highly successful five-ring polyphenyl ether fluid (PWA 524 or Skylube 600) for 500°F oil-in-supersonic engine applications is presented.

(Author)

## A66-20158

### FACTORS INFLUENCING AIRCRAFT TURBINE ENGINE OIL DRAIN PRACTICES.

Donald W. Bedell (Humble Oil and Refining Co., Houston, Tex.). Society of Automotive Engineers, Automotive Engineering Congress, Detroit, Mich., Jan. 10-14, 1966, Paper 660073, 6 p. Members, \$0.75, nonmembers, \$1.00.

Consideration of optimum oil drain time in turbine engine operation. Engine design factors such as heat shielding to minimize hot spots, air flow, and the materials used in engine construction are discussed. Flow restrictions should be reduced to a minimum and a maximum drain time should be established to safeguard the engine. A fleetwide monitoring system is essential for adequate engine control and the detection of mechanically marginal engines. The nature of lubricant degradation is described in terms of sludging, increase in viscosity, increase in acidity, increase in corrosivity, and carbonaceous and varnish deposits. D. P. F.

## A66-20159

### MEANS OF ASSESSING AVIATION TURBINE LUBRICANT QUALITY.

A. E. Smith, G. Cantini, and R. J. De Chard (Socony Mobil Oil Co., Inc., Aviation Dept., New York, N.Y.). Society of Automotive Engineers, Automotive Engineering Congress, Detroit, Mich., Jan. 10-14, 1966, Paper 660074, 10 p. Members, \$0.75; nonmembers, \$1.00.

Review of some general methods in use for measuring turbine lubricant quality. The specification approach in determining lubricant quality is based on product approval against specific requirements issued by engine manufacturers. Inasmuch as overall performance has not been established this method alone is incomplete. The equipment strip approach is based on inspection reports of the internal condition of an engine; quality is here assessed on a performance basis. Measuring lubricant quality on the basis of recorded documentation covering various aspects of overall performance which include maintenance and operational factors is the most effective criterion. This criterion is not a fixed and rigid concept as demands on lubricant quality change with operating conditions. D. P. F.

## A66-20433

### DEVICE FOR TAKING LONG-TIME CORROSION FATIGUE CURVES ON SMALL CROSS-SECTION SPECIMENS AT HIGH TEMPERATURES AND PRESSURES.

A. V. Riabchenkov, V. P. Sidorov, and N. F. Pongil'skii (Tsentral'nyi Nauchno-Issledovatel'skii Institut Tekhnologii i Mashinostroeniia, Moscow, USSR). (Zavodskaya Laboratoriia, vol. 31, Aug. 1965, p. 1019-1020.) Industrial Laboratory, vol. 31, Jan. 1966, p. 1262, 1263. Translation.

Determination of comprehensive quantitative characteristics of the tendency of a metal to corrode under stress, by plotting the curves of the long-time corrosion-fatigue strength. A device for obtaining curves of the long-time corrosion strength on metal specimens in aqueous solutions at elevated temperatures and pressures is described and illustrated, and its operation is explained. It is concluded that for taking a complete curve of the long-time corrosion strength, the activity of the solution in the device must be increased by increasing the concentration of the chloride ions and the oxidation.

B. B.

## A66-20836

### CORROSION OF METALS AND ALLOYS [KORROZIA METALLOV I SPLAVOV].

Edited by N. D. Tomashov and E. N. Mirolubov. Moscow, Izdatel'stvo Metallurgii, 1965. 378 p. In Russian.

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STUDY OF THE CORROSION RESISTANCE AND ELECTRO-CHEMICAL AND MECHANICAL PROPERTIES OF ALLOYS OF THE NIOBIUM-TITANIUM SYSTEM [ISSLEDOVANIE KORROZIONNOI STOIKOSTI, ELEKTROKHIMICHESKIKH I MEKHANICHESKIKH SVOISTV SPLAVOV SISTEMY NIOBII-TITAN]. A. I. Glukhova, V. V. Andreeva, S. G. Glazunov, O. P. Solonina, and V. F. Nikulova, p. 29-42. 8 refs. [See A66-20838 09-17]

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## A66-20837 #

### EFFECT OF ALLOYING ELEMENTS ON THE ANODIC CORROSION AND PASSIVATION OF STAINLESS STEELS [VLIANIE LEGIRUIUSHCHIKH ELEMENTOV NA ANODNOE RASTVORENIE I PASSIVIROVANIE NERZHAVEIUSHCHIKH STALEI].

G. P. Chernova and N. D. Tomashov.

IN: CORROSION OF METALS AND ALLOYS [KORROZIA METALLOV I SPLAVOV].

Edited by N. D. Tomashov and E. N. Mirolubov.

Moscow, Izdatel'stvo Metallurgii, 1965, p. 7-13. 9 refs. In Russian.

Results of a study of the corrosion and electrochemical properties of stainless steel with 25% of Cr and 0.5, 1.0, 2.0, and 3.0 wt% of Ni, Mo, or Re, treated with 1.0 N H<sub>2</sub>SO<sub>4</sub> for 120 hr at 25, 50, or 75°C. It is found (1) that Ni, Mo, and especially Re additions of 0.5 to 3 wt% sharply reduce corrosion of this steel, (2) that Ni, Mo, and Re stimulate passivation - reducing the passivation current by a factor of 6 to 12, and (3) that Ni and Mo slow down anodic corrosion and have virtually no effect on hydrogen cathodic depolarization while Re stimulates both the anodic corrosion and the cathodic depolarization. V. Z.

## A66-20838 #

### STUDY OF THE CORROSION RESISTANCE AND ELECTROCHEMICAL AND MECHANICAL PROPERTIES OF ALLOYS OF THE NIOBIUM-TITANIUM SYSTEM [ISSLEDOVANIE KORROZIONNOI STOIKOSTI, ELEKTROKHIMICHESKIKH I MEKHANICHESKIKH SVOISTV SPLAVOV SISTEMY NIOBII-TITAN].

A. I. Glukhova, V. V. Andreeva, S. G. Glazunov, O. P. Solonina, and V. F. Nikulova.

IN: CORROSION OF METALS AND ALLOYS [KORROZIA METALLOV I SPLAVOV].

Edited by N. D. Tomashov and E. N. Mirolubov.

Moscow, Izdatel'stvo Metallurgii, 1965, p. 29-42. 8 refs. In Russian.

Investigation of the corrosion resistance and electrochemical and mechanical properties of Nb(60 to 100%)-Ti(0 to 40%) alloys treated with 10, 40, 60, 75, and 94% H<sub>2</sub>SO<sub>4</sub> at 40 and 100°C, with 88% (at 40°C) and 60, 75, and 88% H<sub>3</sub>PO<sub>4</sub> at 100°C, with 5 to 30% hydrochloric acid at 40 and 100°C, with 57 and 98% HNO<sub>3</sub> at 100°C, and with 25% oxalic acid at 100°C. Maximum corrosion was established when the potential of the acid media is -100 mv. The high corrosion resistance observed at 40°C in alloys with up to 40% of Ti is found to decrease with temperature. V. Z.

**A66-20839 #**

STUDY OF THE CORROSION RESISTANCE AND ELECTROCHEMICAL AND MECHANICAL PROPERTIES OF ALLOYS OF THE TITANIUM-NIOBIUM SYSTEM [ISSLEDOVANIE KORROZIONNOI STOIKOSTI, ELEKTROKHIMICHESKIH I MEKHANICHESKIH SVOISTV SPLAVOV SISTEMY TITAN-NIOBIU].

V. V. Andreeva, V. I. Kazarin, E. L. Alekseeva, S. G. Glazunov, O. P. Solonina, and V. F. Nikulova.

IN: CORROSION OF METALS AND ALLOYS [KORROZIYA METALLOV I SPLAVOV].

Edited by N. D. Tomashov and E. N. Mirolubov.

Moscow, Izdatel'stvo Metallurgiya, 1965, p. 43-58. In Russian.

Investigation of the microstructure and mechanical and electrochemical properties of Ti(50 to 98%)-Nb(50 to 2%) alloys and their corrosion resistance in  $H_2SO_4$ ,  $H_3PO_4$ ,  $HNO_3$ , hydrochloric acid and oxalic acid. It is found that Nb additions (1) substantially increase the strength and hardness of titanium and its corrosion resistance in solutions of nonoxidizing acids, and (2) do not affect the high corrosion resistance of titanium in oxidizing solutions, such as 57%  $HNO_3$  or mixtures of  $HNO_3$  with hydrochloric acid in proportions 1 to 1 or 2 to 1 at 100°C.

V. Z.

**A66-20840 #**

ELECTROCHEMICAL AND CORROSION BEHAVIOR OF ALUMINUM-BASED BINARY ALLOYS AND INTERMETALLIC COMPOUNDS [ELEKTROKHIMICHESKOE I KORROZIONNOE POVEDENIE DVOINNYKH SPLAVOV I INTERMETALLICHESKIH SOEDINENII NA OSNOVE ALUMINIYA].

A. I. Golubev and M. N. Ronzhin.

IN: CORROSION OF METALS AND ALLOYS [KORROZIYA METALLOV I SPLAVOV].

Edited by N. D. Tomashov and E. N. Mirolubov.

Moscow, Izdatel'stvo Metallurgiya, 1965, p. 59-79. 33 refs. In Russian.

Results of a study of the electrochemical properties and corrosion of Al-based Fe, Ni, Ti, Cu, and Sb binary alloys. Electrolytic dissolution of intermetallic compounds present in these alloys ( $FeAl_3$ ,  $NiAl_3$ ,  $CuAl_2$ ,  $TiAl_3$ ,  $AlSb$ , and  $Mg_2Al_3$ ) is investigated. The maximum potential gradient between two components of these alloys is given as 1 to 15 mv in a 0.1 N solution of NaOH. For alkaline and neutral media, potential/current diagrams of these alloys are constructed from the polarization curves of their components. The diagrams show a good coincidence of calculated and experimental potentials. Factors determining the anodic behavior of these intermetallic compounds in alkaline media at various potential levels are identified.

V. Z.

**A66-20841 #**

STUDY OF THE ELECTROCHEMICAL BEHAVIOR OF TITANIUM [ISSLEDOVANIE ELEKTROKHIMICHESKOGO POVEDENIA TITANA].

N. D. Tomashov, V. N. Modestova, L. A. Plavich, and A. B. Averbukh.

IN: CORROSION OF METALS AND ALLOYS [KORROZIYA METALLOV I SPLAVOV].

Edited by N. D. Tomashov and E. N. Mirolubov.

Moscow, Izdatel'stvo Metallurgiya, 1965, p. 80-102. 21 refs. In Russian.

Investigation of the effect of a surface hydride film produced by corrosion on the electrolytic corrosion and oxidation of titanium. The hydride-oxide nature of titanium passivation in acid solutions, with hydrogen depolarization taking place during corrosion, is established. The passivation is believed to promote titanium stability against acid agents. The hydride surface film is found to depress anodic corrosion of titanium.

V. Z.

**A66-21747 #**

STUDY OF THE CORROSION PROPERTIES OF YTTRIUM. I - EFFECT OF pH ON THE ELECTROCHEMICAL AND CORROSION BEHAVIOR OF YTTRIUM [ISSLEDOVANIE KORROZIONNYKH SVOISTV ITTRIYA. I - VLIYANIE pH NA KORROZIONNOE I ELEKTROKHIMICHESKOE POVEDENIE ITTRIYA].

R. M. Al'tovskii, A. G. Fedotova, and S. I. Korolev.

Zashchita Metallov, vol. 2, Jan.-Feb. 1966, p. 52-56. 8 refs. In Russian.

Investigation of the electrode potential and corrosion of yttrium at pH from 2 to 13 in solutions of  $NaCl(NaNO_3) + HCl(HNO_3)$  and  $NaCl(NaNO_3) + NaOH$ . It is found that the corrosion resistance of yttrium is higher at higher pH, because of a slower anodic process, and decreases in the presence of  $NO_3$  ions and especially in the presence of  $Cl$  ions. At 25°C, corrosion of yttrium is accompanied by both hydrogen polarization and oxygen polarization at pH  $\leq 10$ , and by oxygen polarization at pH  $\geq 11$ .

V. Z.

**A66-21748 #**

ELECTROCHEMICAL AND CORROSION BEHAVIOR OF RHENIUM [KORROZIONNOE I ELEKTROKHIMICHESKOE POVEDENIE RENIIA].

N. D. Tomashov and T. V. Matveeva (Akademiya Nauk SSSR, Institut Fizicheskoi Khimii, Moscow, USSR).

Zashchita Metallov, vol. 2, Jan.-Feb. 1966, p. 57-62. 7 refs. In Russian.

Study of the corrosion behavior of rhenium in  $H_2SO_4$ ,  $HCl$ ,  $H_3PO_4$ ,  $HNO_3$ ,  $NaCl$ ,  $KOH$ ,  $H_2O_2$ , and distilled water at 25 and 100°C. The corrosion rate is found to be negligible at 25°C and very low at 100°C in  $H_2SO_4$ ,  $H_3PO_4$ , and  $HCl$ . In distilled water in the presence of air, corrosion is negligible at 20°C but increases at 100°C to a rate of 0.05 g/m-hr, approaching its rate in  $NaCl$  solutions. Alkali hydroxides have a greater corroding effect and the greatest effect have the oxidizing agents  $HNO_3$  and  $H_2O_2$ . Rhenium corrosion by all these agents is of an electrochemical nature and is determined only by the kinetics of the anodic and cathodic processes involved.

V. Z.

**A66-22040**

DEVELOPMENTS IN HIGH-TEMPERATURE ULTRAHIGH-VACUUM FRICTION STUDIES.

L. G. Kellogg (North American Aviation, Inc., Atomics International Div., Canoga Park, Calif.).

(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65AM 6A1.)

Lubrication Engineering, vol. 22, Feb. 1966, p. 57-66. 13 refs.

[For abstract see issue 14, page 2033, Accession no. A65-24242]

**A66-22303**

DIRECT EVIDENCE FOR THE CATHODIC DEPOLARIZATION THEORY OF BACTERIAL CORROSION.

Warren P. Iverson (U.S. Army, Biological Laboratories, Fort Detrick, Md.).

Science, vol. 151, Feb. 25, 1966, p. 986-988. 7 refs.

Cathodic depolarization of mild steel by Desulfovibrio desulfuricans was demonstrated with benzyl viologen used as an electron acceptor. Direct measurement of the cathodic depolarization current indicated a maximum current density of  $1 \mu a/cm^2$ . Aluminum alloys were also cathodically depolarized by the organism. (Author)

**A66-22470 #**

NONLINEAR BENDING OF A STRESS CORROSION SPECIMEN.

Paul E. Wilson and Edward E. Spier (General Dynamics Corp., General Dynamics/Astronautics, Structures Research Group, San Diego, Calif.).

(American Society of Mechanical Engineers, Aviation and Space Conference, Los Angeles, Calif., Mar. 14-18, 1965, Paper 65-AV-3.)

ASME, Transactions, Series B - Journal of Engineering for Industry, vol. 88, Feb. 1966, p. 31-36. 10 refs.

[For abstract see issue 13, page 1957, Accession no. A65-23464]

**A66-22747 #**

EFFECT OF MOLYBDENUM AND TUNGSTEN ON THE PROPERTIES OF  $Kh25Ni6G7AR$  STEEL [VLIYANIE MOLIBDENA I VOL'FRAMA NA SVOISTVA STALI  $Kh25Ni6G7AR$ ].

A. P. Boiarinova, T. S. Savel'eva, and A. N. Dubrovina (Zavod "Elektrostal", USSR).

Metallovedenie i Termicheskaya Obrabotka Metallov, Jan. 1966, p. 17-19. In Russian.

Investigation of the possibility of improvement of the strength and corrosion resistance of  $Kh25Ni6G7AR$  chromium steel by adding Mo and W. Mo additions are found to improve short-time strength

and the anticorrosion properties of this steel, and W additions increase markedly its endurance limit. Adding of 2.5% Mo and 4% W increases, however, the solubility limit of these elements in the steel, leading to the formation of intermetallide phases which results in brittleness at 700 to 1000°C. V. Z.

#### A66-22951

##### BEARINGS.

Convair Traveler, vol. 17, Jan.-Feb. 1966, p. 3-15.

Survey of the operation, maintenance, and installation of plain (friction) bearings and various types of antifriction bearings. The main characteristics of these different types of bearings are described, and fit tolerances for all types of plain bearings and bushings are given in a table. Some of the most common bearing problems and their causes are listed as a guide to maintenance personnel. Measures to be taken in installing and removing bearings are outlined, and methods of lubricating bearings are discussed. A. B. K.

#### A66-23014

##### CORROSION.

Field Service Digest, Dec. 1965, p. 3-35.

Discussion of the underlying principles of corrosion phenomena, their mode of occurrence, and measures for controlling them. It is noted that consideration of corrosion-prone areas, corrosion detection, and corrosion removal can provide a basis for establishing intelligent procedures to solve individual corrosion problems that arise in service. M. M.

#### A66-23071. #

##### HYDROGEN PERMEATION IN METALS AS A FUNCTION OF STRESS, TEMPERATURE AND DISSOLVED HYDROGEN CONCENTRATION.

W. Beck, J. O'M. Bockris, J. McBreen, and L. Nanis (Pennsylvania, University, Electrochemistry Laboratory, Philadelphia, Pa.). Royal Society (London), Proceedings, Series A, vol. 290, Feb. 22, 1966, p. 220-235. 36 refs.

Navy-supported research.

An investigation of the diffusion of electrolytic hydrogen through membranes of (1) polycrystalline Armco iron, (2) single crystal Armco iron, (3) zone refined iron, and (4) A. I. S. L. 4340 has been made. The temperature and stress dependence of the permeation rate through the first and last of these metals was investigated, while the first three have been investigated under varying concentrations of hydrogen in the metal. From the results concerning Armco iron polycrystals and single crystals, and zone-refined iron it has been concluded that trace impurities and grain boundaries have negligible effects on the hydrogen permeation rate. Stress has been shown not to affect  $D$ , but it increases the solubility of hydrogen in the lattice. The  $D_0$  and  $\Delta H_D$  value for  $\alpha$ -iron and the stress dependence of the hydrogen solubility indicate that the rate-determining step in diffusion is the formation of a cavity (a dilated octahedral hole) to accommodate the diffusion hydrogen. Maxima observed in the relation of the rate of permeation to time were explained in terms of "blister" formation; the temperature dependence of the critical hydrogen concentration necessary to form these blisters is in concordance with this hypothesis. The nucleation sites for such blisters are aggregates of dislocations. The mechanism proposed to explain the maxima in the permeation transients was used to rationalize the existing discrepancies in diffusion data found in the literature. It is suggested that the crack initiation site for stress corrosion cracking may be a highly localized density of dislocations, on a metal surface, generated by blister formation due to hydrogen. (Author)

#### A66-23120

##### STRESS CORROSION OF E-GLASS FIBERS.

G. K. Schmitz and A. G. Metcalfe (International Harvester Co., Solar Div., San Diego, Calif.).

I & EC - Industrial and Engineering Chemistry, Product Research and Development, vol. 5, Mar. 1966, p. 1-8. 13 refs.

Contract No. Nonr-3654(00) (X) A2.

Study of stress corrosion on glass exposed to water vapor. This corrosion has long been assumed to occur on existing surface defects by a continuous process. The present work on glass filaments has shown that incubation and flaw growth by corrosion constitute the two stages preceding fracture. In the incubation

period, water reacts with cations in the glass leading to hydrolysis and increased concentration of hydroxyl ions. The incubation period continues until this concentration reaches the level necessary for corrosion to occur; this stage occupies most of the life of the fiber. Subsequent corrosion of the surrounding silica network takes place until the critical size flaw has formed, when fracture ensues. Stress corrosion was studied on E-glass fibers under constant load in both 50 and 100% relative humidity. Contrary to earlier assumptions, the growth rate of flaws was not controlled by a single exponent governing the growth equation. Stress corrosion occurs during typical tensile tests, and results of such tests were correlated with stress corrosion data. M. F.

#### A66-23123

##### SYNERGISTIC ANTIOXIDANTS FOR SYNTHETIC LUBRICANTS.

T. G. Davis and J. W. Thompson (Eastman Kodak Co., Tennessee Eastman Co., Research Laboratories, Kingsport, Tenn.).

(American Chemical Society, Division of Petroleum Chemistry, Meeting, 149th, Detroit, Mich., Apr. 1965, Paper.)

I & EC - Industrial and Engineering Chemistry, Product Research and Development, vol. 5, Mar. 1966, p. 76-80. 24 refs.

Laboratory oxidation tests disclosed the high activity of alkali metal salts of carboxylic acids and substituted phenols as synergists for arylamine antioxidants in ester-type synthetic lubricating oils for advanced jet engines. The results indicated that such oils would remain relatively stable and sludge-free at considerably higher engine temperatures than oils containing previous antioxidant systems. Similar salts of various other metals were inactive. Extensive testing of a representative oil by the Air Force disclosed good correlation between bearing rig and laboratory oxidation tests at 425°F; however, the oil did not perform well in an actual jet engine test. An investigation of possible causes was inconclusive. One possible but unusual explanation was that the oil performed best when large volumes of air were passed through it. Such aeration occurred during the laboratory and rig tests, but not in the engine test. No mechanism for the interaction between the metal salt and the arylamine antioxidant is known as yet. However, several factors which may be responsible are mentioned. (Author)

#### A66-23647

##### A NEW STRESS-CORROSION CRACKING TEST FOR HIGH-STRENGTH ALLOYS.

B. F. Brown (U.S. Naval Research Laboratory, Metallurgy Div., Physical Metallurgy Branch, Washington, D.C.).

Materials Research and Standards, vol. 6, Mar. 1966, p. 129-133;

Discussion, S. T. Rolfe (United States Steel Corp., Applied Research Laboratory, Monroeville, Pa.) and H. S. Reemsnyder (Bethlehem Steel Co., Homer Research Laboratories, Bethlehem, Pa.), p. 133.

8 refs.

Navy-supported research.

A stress-corrosion cracking test which employs a precracked bar stressed in bending as a cantilever beam is described. One end of the bar is attached to a rigid mast; weights are placed in a pail suspended from an arm attached to the other end of the specimen. The corrosive is contained in a polyurethane cell which surrounds the central cracked portion of the bar. Propagation of the stress-corrosion crack is detected by a standard dial gage. The crack is first provided by machining and is "sharpened" by fatiguing in a machine lathe. Tests conducted on specimens of a martensitic steel and a titanium alloy indicate that, if the other necessary conditions are met, stress-corrosion cracking can be expected to occur if a minimum value of stress  $K_{Isc}$  is exceeded. That titanium alloys do not pit under aqueous conditions at room temperature may be responsible for previous reports that titanium alloys are immune to stress-corrosion cracking at room temperature. (Author)

#### A66-23751

SIMULATION OF THE OIL CIRCULATION IN TURBINE ENGINES AND ITS SIGNIFICANCE IN THE PRACTICAL EVALUATION OF AVIATION TURBINE OILS [DIE SIMULIERUNG DES ÖLKREISLAUFS VON TURBINENTRIEBWERKEN UND SEINE BEDEUTUNG FÜR DIE PRAXISNAHE UNTERSUCHUNG VON FLUGTURBINENÖLEN].

G. Spengler and E. K. Jantzen (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für Flugtrieb- und Schmierstoffe, Munich, West Germany).

Zeitschrift für Flugwissenschaften, vol. 14, Feb. 1966, p. 99-102. In German.

Discussion of the basic conditions under which lubricating oil circulates in aviation turbine engines and examination of the requirements for constructing a model of such oil circuits. A satisfactory model developed by the DVL for representing oil circulation is described. This model includes a bearing simulating device, an apparatus to remove all foam from the oil, an oil reservoir, a cooler, and a heat exchanger for preheating the oil. The experimental results obtained with this simulator are analyzed and it is shown that upon increasing the maximum operating temperature from 150 to 250°C the oil characteristics, such as viscosity, acid number, and electrical conductivity, are changed radically.

D. P. F.

#### A66-23844 #

EXTENSION OF DRAIN PERIODS IN GAS-TURBINE ENGINES USING IMPROVED SYNTHETIC LUBRICANTS.

H. W. Reynolds, Jr. (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).

(Society of Automotive Engineers, National Aeronautics and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 4-8, 1965, Paper 650814.)

Esso Air World, vol. 18, Jan.-Feb. 1966, p. 91-97.

[For abstract see issue 23, page 3491, Accession no. A65-34699]

#### A66-23849 #

EFFECTS OF STRESS WAVE FORMS ON LOW CYCLE CORROSION FATIGUE STRENGTH.

Kichiro Endo and Kenjiro Komai (Kyoto University, Dept. of Mechanical Engineering, Kyoto, Japan).

Kyoto University, Faculty of Engineering, Memoirs, vol. 27, Oct. 1965, p. 415-432, 7 refs.

Study of the effect of trapezoidal stress waveforms on low-cycle corrosion fatigue strength in order to clarify the mechanism of corrosion fatigue. The fatigue tests were carried out with a carbon steel and an aluminum alloy. A 1% NaCl aqueous solution was used as the corrosive environment. In the testing machine, trapezoidal stress waves were formed mechanically, and the stress rate, stressless time, and maximum stress time were variable.

F. R. L.

#### A66-24099

SOLID AND BONDED-FILM LUBRICANTS.

Alfred DiSapio and Harry S. Gerstung (Dow Corning Corp., Midland, Mich.).

Machine Design, vol. 38, Mar. 10, 1966, p. 8-11.

Discussion of solid and dry-film lubricants. The basic requirements of a boundary lubricant are reviewed. Solid lubricant kinetic coefficients of friction are tabulated. Also tabulated are the principal solid lubricants of industrial importance and their characteristics. These include molybdenum disulfide, graphite powder, and TFE fluorocarbons. The choice of lubricant depends on several factors which are discussed separately: particle size, viscosity or consistency, availability, and compliance with military specifications. The characteristics of dry-film lubricants are discussed and representative bonded lubricant coatings are tabulated. Application conditions which call for solid lubricants are high load, low sliding velocity, wear life, high temperature, high vacuum, radiation, and pressure. A discussion is included of the cost, method of application and surface preparation of dry films.

M. F.

#### A66-24100

POWDER-METAL BEARINGS.

Edward T. Johnson (Chrysler Corp., Amplex Div., Detroit, Mich.).

Machine Design, vol. 38, Mar. 10, 1966, p. 40-44.

Discussion of custom powder-metal bearings and the ranges of suitable shapes, sizes, and proportions that are practical for manufacture. The configurations of powder-metal bearings are reviewed. Bearing dimensions discussed include sleeve, flange and thrust bearings, chamfers and densities. The dimensional tolerances for bronze and iron-base powder-metal bearings are tabulated. The design and installation procedure of powder-metal bearings is

outlined. A convenient method of computing limits of bearing ID and clearance is described.

M. F.

#### A66-24383

LUBRICATION IN A VACUUM.

Donald H. Buckley (NASA, Lewis Research Center, Space Environment Unit, Cleveland, Ohio) and Robert L. Johnson (NASA, Lewis Research Center, Lubrication Branch, Cleveland, Ohio).

Machine Design, vol. 38, Mar. 17, 1966, p. 164-169.

Description of the effects of a vacuum on lubricants and bearing materials. A vacuum differs from a normal atmospheric environment in two important respects: (1) ambient pressure is reduced, and (2) the concentration of oxidizing gases is lower. These differences account for the effects of a vacuum environment on both lubricants and lubricated components. The reduced ambient pressure affects the evaporation rate of the lubricant. Other factors which influence the evaporation of oils are temperature and the relation of the evaporation rate of the lubricant to its molecular weight. The effects of vacuum on the lubricated components are studied. Recommendations are made for lubricant selection and system design. The possible cold welding of metals upon loss of lubricants suggests that mechanical components for such systems should be constructed of metals and alloys having little tendency to weld.

M. F.

#### A66-24425 #

MAGNETOHYDRODYNAMIC THEORY OF THE LUBRICATION OF A CYLINDRICAL BEARING [MAGNETOHIDRODINAMICHESKAYA TEORIYA SMAZKI TSILINDRICHESKOGO PODSHIPNIKA].

I. A. Shvarts.

Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza.

Jan.-Feb. 1966, p. 9-15, 14 refs. In Russian.

Solution of a plane magnetohydrodynamic problem of the pressure distribution of a viscous electrically conducting fluid in the lubrication layer of a cylindrical bearing. A constant magnetic field is assumed to be directed along the axis of the bearing with a potential difference being applied between the pivot and the bearing from an external source. Since the radial gap in the bearing is not assumed to be small, the problem is reduced to a two-dimensional system of magnetohydrodynamics equations. An expression is obtained for the additional pressure in the lubrication layer caused by electromagnetic forces. In the special case of a very thin layer a previously obtained result is confirmed.

A. B. K.

#### A66-24550 #

A THEORY OF LUBRICATION BY MICROIRREGULARITIES.

D. B. Hamilton, J. A. Walowit, and C. M. Allen (Battelle Memorial Institute, Columbus, Ohio).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper 65 - Lub-11.)

ASME, Transactions, Series D - Journal of Basic Engineering, vol. 88, Mar. 1966, p. 177-185, 10 refs.

[For abstract see issue 04, page 527, Accession no. A66-14244]

#### A66-24900 #

EFFECT OF HEAT TREATMENT ON THE STRUCTURE AND PROPERTIES OF VT1 TITANIUM AND OT4 ALLOY [VLIYANIE TERMICHESKOI OBRABOTKI NA STRUKTURU I SVOISTVA TITANA VT1 I SPLAVA OT4].

A. P. Akshentseva and G. N. Shumratova.

Metallovedenie i Termicheskaya Obrabotka Metallov, Feb. 1966, p. 51-55, In Russian.

Investigation of the effect of various heat treatments on the structure, hardness, microhardness, and corrosion resistance of 1.5 to 14 mm sheets of VT1 titanium and 1.5 to 5 mm sheets of OT4 titanium-manganese-aluminum industrial alloy. Heating in air noticeably increased the hardness of VT1. The formation of an oxide layer up to 15  $\mu$  thick with a 10  $\mu$  diffusion sublayer was established in both alloys following 2 hr heating at 750 to 850°C. A hard oxide surface layer is formed on both alloys when they are heated from 950 to 1050°C.

V. Z.

## A66-24929

### A66-24929 \*

#### A NEWLY-EQUIPPED TEST RIG FOR GAS-LUBRICATED JOURNAL BEARINGS AND SOME OF ITS TEST RESULTS.

Norimune Soda, Hitoshi Marumo, and Shinobu Saito.  
Tokyo, University, Institute of Space and Aeronautical Science,  
Bulletin, vol. 1, no. 4(B), Dec. 1965, p. 499-509. In Japanese.

Description of the details of a test rig for studying the general performance of a 50 mm  $\phi$  x 100 mm gas-lubricated journal bearing which can be operated at speeds up to 20,000 rpm. Certain problems encountered during the preliminary testing of this facility are also mentioned. By its use, such factors can be measured as frictional torque, pressure distribution in the gas film, and the static and dynamic changes of eccentricity, both in hydrodynamically and hydrostatically lubricated conditions. B.B.

### A66-24986

#### A NEW SYNTHETIC HYDROCARBON LUBRICANT FOR EXTREME-TEMPERATURE APPLICATIONS.

I. N. Duling, J. Q. Griffith, and R. S. Stearns (Sun Oil Co., Research and Development Div., Marcus Hook, Pa.).  
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-1.)

ASLE Transactions, vol. 9, Jan. 1966, p. 1-10; Discussion, K. R. Bunting, T. P. Traise (American Oil Co., Whiting, Ind.), and A. Beerbower (Esso Research and Engineering Co., Products Research Div., Linden, N.J.), p. 11; Authors' Closure, p. 11, 12, 32 refs.

[For abstract see issue 02, page 238, Accession no. A66-12259]

### A66-24989

#### METHYL ALKYL SILICONES - A NEW CLASS OF LUBRICANTS.

E. D. Brown, Jr. (General Electric Co., Silicone Products Dept., Waterford, N.Y.).  
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-4.)

ASLE Transactions, vol. 9, Jan. 1966, p. 31-35. 7 refs.

[For abstract see issue 02, page 238, Accession no. A66-12261]

### A66-24993

#### STUDY OF CORROSIVITY AND CORRELATION BETWEEN CHEMICAL REACTIVITY AND LOAD-CARRYING CAPACITY OF OILS CONTAINING EXTREME PRESSURE AGENTS.

Tochio Sakurai (Tokyo Institute of Technology, Tokyo, Japan) and Kachio Sato (Nippon Mining Co., Ltd., Central Research Laboratory, Toda-machi, Saitama-ken, Japan).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-11.)

ASLE Transactions, vol. 9, Jan. 1966, p. 77-85; Discussion, P. A. Asseff (Lubrizol Corp., Cleveland, Ohio) and N. E. Gallopoulos (General Motors Corp., Research Laboratories, Warren, Mich.), p. 86, 87; Authors' Closure, p. 87.

[For abstract see issue 02, page 237, Accession no. A66-12254]

### A66-24999

#### DYNAMIC BEHAVIOR OF ROTATING SHAFTS WITH ALLOWANCES FOR THE ELASTICITY OF THE LUBRICATING FILM IN THE BEARINGS - THE UNSYMMETRICAL SHAFT WITH A SINGLE DISK [DAS DYNAMISCHE VERHALTEN VON ROTIERENDEN WELLEN UNTER BERÜCKSICHTIGUNG DER SCHMIERFILMELASTIZITÄT IN DEN LAGERN - DIE UNSYMMETRISCHE, EINFACH BESETZTE WELLE].

Herbert Pfützner.

Forschung im Ingenieurwesen, vol. 32, no. 1, 1966, p. 19-28. 7 refs. In German.

Investigation of the effect of oil cushion resilience in hydrodynamic bearings on the dynamic behavior of an unsymmetrical shaft with one disk - i.e., on a shaft with two bearings, which may be different, and one disk at an arbitrary position. Oil cushion resilience can shift the critical speeds of bending; the anisotropic oil-film elasticity can cause the motion of the shaft to become unstable. The equations of motion are derived and solved for shafts with end bearings. The eigenvalues of the dynamic behavior of a

simple anisotropically supported shaft are developed. A generalized expression is obtained for the stability boundary of shafts supported by bearings at two points. D.P.F.

### A66-25303

#### COMPRESSION AND FRICTION PROPERTIES OF RIGID POLYURETHANE FOAMS.

N. Chessin and W. E. Driver (Martin Marietta Corp., Martin Co., Orlando, Fla.).

IN: SOCIETY OF PLASTICS ENGINEERS, ANNUAL TECHNICAL CONFERENCE, 22ND, MONTREAL, CANADA, MARCH 7-10, 1966 TECHNICAL PAPERS. VOLUME 12. [A66-25301 13-18]

Conference sponsored by the Quebec Section of the Society of Plastics Engineers.

Stamford, Conn., Society of Plastics Engineers, Inc., 1966. 6 p.

Analysis of sliding friction and compression tests of a series of rigid polyurethane foams. Although the elastic region appeared to vary from 5 to 10% of the initial deflection, the stress-strain curve between 1 and 2% compression formed a very straight line. To develop engineering-type design data, the modulus of the straight line portion of the curve was evaluated as a function of foam density, direction of foam rise, strain rate, and thickness of samples tested. The effects of the presence of molded skins were also examined, and friction tests were conducted with three types of surfaces against painted steel. It is concluded that foams may be selected for structural applications on the basis of their compression moduli, and that the rate of load application up to 177 in./in./min does not seem to affect the materials or change the response to loads. B.B.

### A66-25367

#### INFLUENCE OF SURFACE ROUGHNESS ON BOUNDARY FRICTION.

Yukio Miyakawa (National Aerospace Laboratory, Tokyo, Japan).  
(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Preprint 65 AM 6AZ.)

Lubrication Engineering, vol. 22, Mar. 1966, p. 109-116. 7 refs.  
[For abstract see issue 14, page 2035, Accession no. A65-24258]

### A66-25771

#### SHOT PEENING FOR RESISTANCE TO STRESS-CORROSION CRACKING.

H. W. Zoeller and B. Cohen (USAF, Systems Command, Research and Technology Div., Materials Laboratory, Wright-Patterson AFB, Ohio).

(American Society for Metals, Metals/Materials Congress, Detroit, Mich., Oct. 18-22, 1965, Paper.)

Metals Engineering Quarterly, vol. 6, Feb. 1966, p. 16-20.

The increased emphasis by the Air Force in the area of corrosion prevention and control is discussed. Typical stress-corrosion cracking failures are described. Attention is directed to the importance of extensive use of shot peening to reduce susceptibility to stress-corrosion cracking and to improve fatigue life of landing gears, wing spars, jet engine components, and other structural parts. The more extensive use of ultrahigh-strength alloys in Air Force systems has increased the importance and value of shot peening. (Author)

### A66-25779

#### CURRENT STATUS OF COMPOSITE CASTING AS BONDING TECHNIQUE.

J. H. Beile and C. H. Lund (Martin Marietta Corp., Martin Metals Div., Wheeling, Ill.).

(American Society for Metals, Metals/Materials Congress, Detroit, Mich., Oct. 18-22, 1965, Paper.)

Metals Engineering Quarterly, vol. 6, Feb. 1966, p. 63, 64.

Discussion of composite casting, a method of metallurgical bonding which can be considered as a modification of foundry practice wherein the molten alloy is poured into a casting mold for the purpose of bonding with one or more inserts of similar or dissimilar alloys. Details of the technique are presented. Use of the method permits the designer to take best advantage of the specific merits of each alloy. Some of the advantages are weight reduction and improved corrosion resistance. F.R.L.

### A66-25883

#### EFFECT OF CORROSIVE AND SURFACE-ACTIVE MEDIA ON THE FATIGUE STRENGTH OF ALUMINUM ALLOYS.

A. V. Karlashov, A. D. Gnatiuk, and V. P. Tokarev (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR). (Fiziko-Khimicheskaya Mekhanika Materialov, vol. 1, no. 1, 1965, p. 7-11.)  
Soviet Materials Science, vol. 1, Jan.-Feb. 1965, p. 1-4. 5 refs.  
 Translation.

Experimental study of the effect of corrosive and surface-active media on the fatigue strength of aluminum alloys D16 and V95, which are widely used in aircraft construction. Fresh water and a 3% solution of NaCl were chosen to simulate sea water. As the surface-active medium, liquid AMG-10 was chosen, which is used in hydraulic systems of aircraft, activated with 2% oleic acid. The metals were tested at 6000 stress reversals per min with a test base of  $20 \times 10^6$  cycles. The smooth, round testpieces were prepared to industrial specifications in accordance with Soviet Standard GOST 2860-45 from bars of D16 and V95 from the same melt. The chemical composition and mechanical properties of the materials tested are tabulated. Analysis of the fatigue tests on the alloys D16 and V95 exposed to corrosive and surface-active media indicates that these media lower the fatigue strength of the materials in question. B. B.

#### A66-25884

##### LUBRICATING OIL ADDITIVES AND THEIR FUNCTION IN FRICTION PROCESSES.

B. I. Kostetskii, L. F. Kolesnichenko, Iu. D. Ostrovoi, M. E. Natanson, K. Z. Skarchenkov, and P. K. Topekha (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR). (Fiziko-Khimicheskaya Mekhanika Materialov, vol. 1, no. 1, 1965, p. 32-39.)  
Soviet Materials Science, vol. 1, Jan.-Feb. 1965, p. 20-25. 13 refs.  
 Translation.

Study of the structural changes that occur in metal surface layers under boundary friction conditions in the presence of surface-active substances. Observations are made of the changes in fine structure characteristics of the surface layers and of the correlation of these changes with the total frictional heat balance, the characteristics of the rubbing surfaces, and certain of the friction parameters. It is shown that a surface-active medium (pure vaseline oil with a 0.2% oleic acid addition) has a marked effect on the degree of plastic deformation and resultant work hardening; it also causes an increase in the dislocation density, reduces the block dimensions, and changes the dislocation structure. Rolling and sliding friction tests led to similar conclusions; showing that the presence of surface active substances gives rise to heavier plastic deformation reflected in higher hardness values and more severe distortion of the metal structure. B. B.

#### A66-25887

##### STUDY OF DISLOCATION STRUCTURE FOR STATIC AND DYNAMIC FRICTION.

B. I. Kostetskii and P. V. Nazarenko (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR). (Fiziko-Khimicheskaya Mekhanika Materialov, vol. 1, no. 1, 1965, p. 73-77.)  
Soviet Materials Science, vol. 1, Jan.-Feb. 1965, p. 49-52. 7 refs.  
 Translation.

Analysis of the mechanism of plastic deformation in crystalline bodies. The static and dynamic frictional forces are investigated in relation to the dislocation structure of the bodies in contact. Static and dynamic friction are studied for the alkali halides NaCl, KCl, KBr, KI, and LiF, and also for zinc crystals. The friction was created on a machine which allowed the normal load and sliding rate to be varied over a wide range. Experiments were made using the friction of a single indenter along the (100) planes of the crystals, and values indicating the variation of static and dynamic friction with normal pressure for LiF and Zn at a rate of 0.0001 m/sec for a single passage of the indenter are plotted. B. B.

#### A66-25912 =

##### EFFECT OF THE ORIENTATION AND CRYSTALLINITY ON FRICTION AND WEAR OF POLYTETRAFLUOROETHYLENE [VLIVANIE ORIENTATSII I KRISTALLICHNOSTI NA TRENIIE I IZNOS POLITE-TRAFTORETILENA].

G. A. Gorokhovskii and I. I. Agulov (Kievskii Institut Grazhdanskoi Aviatzii, Kiev, Ukrainian SSR). Mekhanika Polimerov, no. 1, 1966, p. 87-92. 8 refs. In Russian.

Experimental study of the effect of the crystalline state and structural orientation of the polymer on the endurance of couplings with polytetrafluoroethylene (PTFE) components. Dry friction and wear on metal-polymer interfaces are investigated for polymer components made of materials crystallized to 33, 40, 60, 71, 88, and 95%. The phase composition of a polymer is found to be a major factor of wear. The existence of an optimum crystallinity level is established; this level varies with the character of friction and load. V. Z.

#### A66-26026

##### THE MECHANISM OF CORROSION OF MAGNESIUM-ZINC ALLOYS. I. K. Marshakov, Ia. A. Ugai, and V. I. Vigdorovich (Voronezhskii Gosudarstvennyi Universitet, Voronezh, USSR).

(Zashchita Metallov, vol. 1, Mar.-Apr. 1965, p. 190-194.)  
Protection of Metals, vol. 1, Mar.-Apr. 1965, p. 161-164. 6 refs.  
 Translation.

Study of the corrosion of alloys of the Mg-Zn system in halide solutions, and comparison of the results obtained with the phase diagram. In processing the results, the composition diagram of Hume-Rothery and Kaufmann was used. M. M.

#### A66-26281

##### ANTI-FRICTION BEARINGS. (2nd Edition).

H. T. Morton.  
 Ann Arbor, Mich., H. T. Morton, 1965. 512 p.  
 \$12.

This is a comprehensive book on the various aspects of anti-friction bearings. It was written for machine designers, manufacturers, and engineers. Tables include such items as fits, standard shoulder heights, and dimensions of mating parts, required data for the proper mounting of bearings. Typical applications and mountings are shown for the various bearing types. Topics discussed include ball bearings, roller bearings, thrust bearings, bearing capacity and selection, miniature and instrument bearings, and completion of bearing life. M. F.

#### A66-26304 #

##### THE FRICTION AND LUBRICATION OF POLYMERS.

S. C. Cohen and D. Tabor (Cambridge, University, Cavendish Laboratory, Cambridge, England).  
Royal Society (London), Proceedings, Series A, vol. 291, Apr. 5, 1966, p. 186-207. 23 refs.

Research supported by the Imperial Chemical Industries.

Study of the friction of a typical polar polymer, nylon, and of a typical nonpolar polymer, polyethylene. The friction of unlubricated surfaces varies with load and geometry in a manner that can be explained in terms of the multiasperity model of Howell and Lodge, modified to allow for a deformation mode that is intermediate between elastic and plastic deformation. Nylon is markedly plasticized by water and its effect as it diffuses into the bulk of the polymer has been studied using hardness measurements. Initially the water produces a softening restricted to the surface layers and this leads to a modest reduction in friction. After a protracted period the bulk softening of the polymer causes an increase in the area of contact and the friction again rises. Polyethylene surfaces are lubricated by surface films of oleamide or stearamide. These materials may also be incorporated, in small quantities, within the bulk of the polymer and can diffuse to the surface to provide an effective lubricating layer. M. M.

#### A66-26973 #

##### STRESS-CORROSION SUSCEPTIBILITY OF HIGH-STRENGTH STEEL, IN RELATION TO FRACTURE TOUGHNESS.

J. H. Mulherin (U.S. Army, Pitman-Dunn Research Laboratories, Frankford Arsenal, Philadelphia, Pa.).  
American Society of Mechanical Engineers, Metals Engineering Conference, Cleveland, Ohio, Apr. 18-22, 1966, Paper 66-Met-5. 6 p. 10 refs.

Members, \$0.75; nonmembers, \$1.50.

The stress-corrosion susceptibility of several ultrahigh-strength ferrous alloys is described on the basis of fracture-mechanics parameters. Two general conditions were considered: first, the susceptibility of a material at various levels of tensile yield strength and fracture toughness; and second, the susceptibility as a function

## A66-27774

of applied subcritical stress-intensity levels. Experimentally, a notched and fatigue-cracked bend-bar specimen configuration was used. Under a subcritical load, fracture of the specimen occurs upon sufficient environmentally influenced crack extension. The susceptibility criterion adopted in this investigation was the time period to catastrophic fracture of the specimen. The results are evaluated in terms of strength level and fracture toughness, and the usefulness of the data generated is examined in terms of material evaluation and application. (Author)

## A66-27774

### EVALUATION OF SOLID LUBRICANT DISPERSIONS ON A FOUR-BALL TESTER.

A. J. Stock (Acheson Colloids Co., Inc., Port Huron, Mich.). (American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 4-7, 1965, Paper.)  
Lubrication Engineering, vol. 22, Apr. 1966, p. 146-151; Discussion, D. R. Wilson and V. Hopkins (Midwest Research Institute, Kansas City, Mo.), p. 151, 152; Author's Closure, p. 152. 14 refs.

Results of four-ball wear tests undertaken on a series of solid-lubricant dispersions in order to ascertain the variables involved in this type of testing. After determining that the length of a run can be set at one minute, with loads over the "apparent critical stress" (ACS), a new method of measuring wear under boundary conditions is proposed. With the aid of this method, which involves multiple one-minute runs at two pressures higher than the ACS, the differences in the performance of various grades of molybdenum disulfide are determined. Suggestions concerning the means used to record the data are made in an effort to improve the accuracy of the method. A. B. K.

## A66-27934

### EXPERIMENTAL OBSERVATION OF A TYPICAL CASE OF FRICTION CORROSION ON A LIGHT ALLOY [OBSERVATION EXPERIMENTALE D'UN CAS TYPIQUE DE CORROSION DE FROTTEMENT SUR UN ALLIAGE LEGER].

Jean-Claude Gourjault, René Lachenaud, and Robert Courtel (Sud-Aviation, Laboratoire Central Courbevoie; Centre National de la Recherche Scientifique, Centre Technique d'Analyse des Surfaces de Frottement, Bellevue, Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques, vol. 262, no. 13, Mar. 28, 1966, p. 776-779. 5 refs. In French.

Study of the development of friction corrosion caused by the alternate pivoting of a steel ball on a plane made of light alloy. The mechanism of destruction is observed and analyzed, and the correlation with a case of practical interest is established. A. B. K.

## A66-28006 #

### MATERIALS FOR SPACE RATING ELECTROMECHANICAL COMPONENTS.

J. E. Kingsbury (NASA, Marshall Space Flight Center, Materials Div., Huntsville, Ala.) and E. C. McKannan (NASA, Marshall Space Flight Center, Materials Div., Engineering Physics Branch, Huntsville, Ala.).

IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, AND AMERICAN SOCIETY OF MECHANICAL ENGINEERS, STRUCTURES AND MATERIALS CONFERENCE, 7TH, COCOA BEACH, FLA., APRIL 18-20, 1966. TECHNICAL PAPERS. [A66-27986 14-32]

New York, American Institute of Aeronautics and Astronautics, 1966, p. 208-215. 16 refs.

Discussion of developments of critical nonstructural materials, specifically lubricants, sliding electrical contacts, and dielectrics. The limitations of hydrocarbon and synthetic lubricants are discussed, and a development program for stable solid lubricants is outlined. A result of the program has been the development of sliding electrical contact materials (an area where problems were first encountered in high-altitude aircraft). The growth of aerospace technology has extended the environment to include not only reduced pressure but particulate radiation. It is shown to be feasible to use unprotected sliding electrical contact materials in space vehicles, as well as in satellite and planetary exploration equipment. The problem of dielectric failures, which have resulted in more functional satellite problems than any other type of material failure, is discussed with reference to wire and cable insulation, potting and conformal coating compounds, and encapsulants and varnishes.

Their roles in dc motors, and the advantages of such motors in space are considered. F. R. L.

## A66-28010 #

### THE EFFECT OF EXPLOSIVE DEFORMATION ON THE STRESS-CORROSION AND MECHANICAL PROPERTIES OF 7075 ALUMINUM ALLOY.

A. J. Jacobs (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).

IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, AND AMERICAN SOCIETY OF MECHANICAL ENGINEERS, STRUCTURES AND MATERIALS CONFERENCE, 7TH, COCOA BEACH, FLA., APRIL 18-20, 1966. TECHNICAL PAPERS. [A66-27986 14-32]

New York, American Institute of Aeronautics and Astronautics, 1966, p. 243-255. 11 refs.

Contract No. NAS 7-162.

The yield strength of 7075-T73 aluminum has been increased to the 70,000-psi level by explosively shocking at 204 Kb. After deformation, this material maintains its excellent stress-corrosion resistance in a saline environment. Similar strengthening should occur in shocked 7075-T6, if precautions are taken to prevent overaging at room temperature. The shock loading also confers excellent stress-corrosion resistance upon the -T6. If solution-treated 7075 is first shocked and then given a -T6 aging treatment, it has poor stress-corrosion resistance. This poor resistance is attributed to the pinning of dislocations by particles precipitating out during aging. Shocked 7075-T6 and -T73 are believed to have high resistance, because they contain enough unpinning or weakly pinned dislocations to permit localized plastic deformation in the vicinity of grain boundary pits. A mechanism to explain the stress-corrosion cracking of 7075 is proposed, in which dislocations are assigned an essential role in the initiation stage of the cracking process. Transmission electron microscopy has disclosed the same sort of dislocation substructure in each of the three 7075 conditions studied. This is characterized by a high density and uniform distribution of dislocations, and the presence of numerous loops. (Author)

## A66-28196 #

### INVESTIGATION OF THE SEIZING OF SAP MATERIALS [ISSLEDOVANIYE SKHVATYVANIYA MATERIALA SAP].

G. S. Sakharov, V. F. Manuilov, and A. M. Galkin.

IN: MECHANICAL WORKING OF LIGHT ALLOYS [OBRABOTKA DAVLENIEM LEGKIKH SPLAVOV].

Edited by A. I. Kolpashnikov.

Moscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsonnyi Tekhnologicheskii Institut, Trudy, no. 62, 1965), p. 38-47.

In Russian.

Investigation of the seizing effect at interfaces SAP-SAP (sintered aluminum powder) and SAP-Al by pressing cylindrical dies into sheets or by forcing together rods of these materials under load. The experimental setup and technique are described. Optimum thermomechanical conditions for intense seizure at SAP-SAP interfaces are indicated. V. Z.

## A66-28197 #

### SEIZING OF STRUCTURAL ELEMENTS [SKHVATYVANIYE ELEMENTOV KONSTRUKTSII].

G. S. Sakharov, A. I. Kolpashnikov, and V. F. Manuilov.

IN: MECHANICAL WORKING OF LIGHT ALLOYS [OBRABOTKA DAVLENIEM LEGKIKH SPLAVOV].

Edited by A. I. Kolpashnikov.

Moscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsonnyi Tekhnologicheskii Institut, Trudy, no. 62, 1965), p. 48-56.

In Russian.

Results of experimental studies of a technique for connecting individual structural elements into nondetachable structures with the aid of seizing phenomena. Pipes and rods of SAP and Al-alloys were used in the experiments to determine the effect of technical parameters on the quality of permanent connections. Conditions are outlined for obtaining one-piece structures from elements of various configurations. V. Z.

**A66-28202 =**

INVESTIGATION OF METAL FLOW DURING THE STAMPING OF THIN PARTS [ISSLEDOVANIE TECHENILA METALLA PRI IZGOTOVLENI DETALEI MALYKH TOLSHCHIN SHTAMPOVKOI].

N. G. Evlanov and G. S. Sakharov.

IN: MECHANICAL WORKING OF LIGHT ALLOYS [OBRABOTKA DAVLENIEM LEGKIKH SPLAVOV].

Edited by A. I. Kolpashnikov.

Moscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsonnyi Tekhnologicheskii Institut, Trudy, no. 62, 1965), p. 101-115.

In Russian.

Investigation of the performance of various lubricants in the upsetting of VT3-1 titanium alloy blanks (8 mm high, 54 mm in diameter) in an upset forging machine at 800 to 1000°C under a load of 1500 tons. The friction coefficient was determined and the macrostructure of upset products was examined following the use of machine oil, colloidal graphite, aluminum powder, water glass, barium chloride, an aviation lacquer, and an aviation enamel as lubricants. It is found that  $BaCl_2$  and AEB enamel are suitable lubricants and that the friction coefficient could be determined most accurately by measuring tangential and normal stresses in an experimental device. The device and procedure are described.

V. Z.

**A66-28207 =**

INVESTIGATION OF INDUSTRIAL LUBRICANTS IN HOT STAMPING [ISSLEDOVANIE TEKHNOLOGICHESKIKH SMAZOK DLIA GORIACHEI SHTAMPOVKI].

G. S. Sakharov.

IN: MECHANICAL WORKING OF LIGHT ALLOYS [OBRABOTKA DAVLENIEM LEGKIKH SPLAVOV].

Edited by A. I. Kolpashnikov.

Moscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsonnyi Tekhnologicheskii Institut, Trudy, no. 62, 1965), p. 160-171.

In Russian.

Investigation of the performance of 26 lubricants in experiments with upsetting of cylindrical samples in a conical matrix. The various individual lubricants are assessed in terms of thermal stability, prevention of adhesion, stress and die wear reduction, and air pollution.

V. Z.

**A66-28465 #**

OBSERVATIONS ON SOME EXPERIMENTAL LUBRICATION PARAMETERS. I [BETRACHTUNGEN ÜBER EINIGE EXPERIMENTELLE SCHMIERUNGSPARAMETER. I].

Gh. Vasilca (Rumänische Akademie, Institut für Strömungsmechanik, Bucharest, Rumania).

Revue Roumaine des Sciences Techniques, Série de Mécanique

Appliquée, vol. 10, no. 6, 1965, p. 1385-1401, 13 refs. In German.

Investigation of some lubrication parameters with respect to their experimental values and their reproducibility. Such parameters as load coefficient, oil quantity, coefficient of friction, and bearing temperature are studied.

R. A. F.

**A66-28466 #**

ASPECTS OF WEAR EVOLUTION RELATED TO THE STATISTICAL CHARACTER OF THE RADIOACTIVE ISOTOPE MEASURING TECHNIQUES.

Dan Pavelescu (Rumanian Academy, Centre of the Mechanics of Solids, Bucharest, Rumania).

Revue Roumaine des Sciences Techniques, Série de Mécanique

Appliquée, vol. 10, no. 6, 1965, p. 1403-1420, 22 refs.

Discussion of aspects pertaining to the correlation of the dynamic and statistical laws of the evolution of the sliding wear process. Consideration is given to the reproducibility of experimental determinations using radioactive tracers.

F. R. L.

**A66-29407 #**

THE MAGNETOHYDRODYNAMIC INCLINED SLIDER BEARING.

Sahib Singh Chawla (Institute of Technology, Dept. of Mathematics, Kharagpur, India).

Japanese Journal of Applied Physics, vol. 5, Mar. 1966, p. 234-237, 9 refs.

Research supported by the Institute of Technology.

Analysis of the MHD inclined slider bearing with an azimuthal magnetic field. The inclined slider bearing under a variable magnetic field is discussed, where the magnetic field is produced by an isolated line current along the line of intersection of the bearing

surface and the slider. It is shown that the load capacity can be appreciably increased by such an arrangement. The results are in contrast to those of Elco and Hughes in the case of a tangential or transverse applied magnetic field.

M. L.

**A66-29418**

HOW DISLOCATIONS AFFECT STRESS CORROSION CRACKING IN ALUMINUM ALLOYS.

Alvin J. Jacobs (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).

Metal Progress, vol. 89, May 1966, p. 80, 81.

Study of the problem of stress corrosion failures in aluminum forging alloys, particularly 7075. During an electron-microscopic study of this alloy, ways were found to distinguish material in the T6 condition (quenched from 895 F and aged for 24 hr at 250°F) from that in the T73 condition (slightly overaged). The first finding was expected on the basis of classic aging behavior: the precipitate responsible for hardening is larger and more widely dispersed in T73 material (which has the greater resistance to stress corrosion). The second difference was unexpected: T6 material (which is stronger, but has little resistance to stress corrosion) contains numerous dislocations, while the 7075-T73 is dislocation-free. Causes of corrosion and of stress concentration are reviewed.

M. F.

**A66-29723 #**

STRESS CORROSION TESTING OF ALLOYS.

A. W. Loginow (United States Steel Corp., Applied Research Laboratory, Monroeville, Pa.).

Materials Protection, vol. 5, May 1966, p. 33-39, 10 refs.

Discussion of the factors governing the selection of test conditions and specimen types for the stress-corrosion testing of alloys. The types of specimens used in such testing are described, and their advantages and disadvantages are analyzed in relation to the type of alloy and its intended use. The parameters used to describe the stress-corrosion behavior of alloys are explained.

R. A. F.

**A66-29724**

CORROSION OF MAGNESIUM IN AQUEOUS MEDIA.

Joseph J. Hydock (Hughes Aircraft Co., Research and Development Div., Materials Technology Dept., Culver City, Calif.).

Materials Protection, vol. 5, May 1966, p. 58-61, 14 refs.

Description of a program for screening inhibited aqueous coolants for an aircraft cooling system of AZ31B magnesium which might also incorporate such metals as copper, aluminum, and stainless steel. The program included static beaker tests and a dynamic test using regenerated deionized water. The corrosion data obtained from the tests are tabulated.

R. A. F.

**A66-30253**

THE FRICTIONAL PROPERTIES OF SILICON NITRIDE AND SILICON CARBIDE.

C. A. Brookes and M. Imai (Cambridge, University, Cavendish Laboratory, Cambridge, England).

IN: SPECIAL CERAMICS 1964: PROCEEDINGS OF THE BRITISH CERAMIC RESEARCH ASSOCIATION SYMPOSIUM, 3RD, STOKES-ON-TRENT, STAFFS., ENGLAND, JULY 8-10, 1964. [A66-30244 16-18]

Edited by P. Popper.

London-New York, Academic Press, 1965, p. 259-266; Discussion, p. 267, 268, 18 refs.

The frictional properties of reaction-sintered silicon nitride and silicon carbide have been studied during reciprocating, sliding between a hemispherical stylus and a polished horizontal specimen. The effects of changes in the load, temperature, and the possibility of lubricating these materials have been investigated and are discussed. Measurements were made in normal atmospheric conditions and at pressures of approximately  $10^{-5}$  torr. Comparisons are drawn between the frictional properties of these compounds and those of other refractory compounds.

(Author)

**A66-30402**

PERFORMANCE OF HIGH SPEED BALL BEARINGS WITH JET OIL LUBRICATION.



## A66-30405

R. J. Matt and R. J. Giannotti (General Motors Corp., New Departure-Hyatt Bearings Div., Bristol, Conn.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 1B4. 22 p.  
Members, \$0.60; nonmembers, \$1.20.

Jet-oil lubrication and scavenging techniques for a 20 mm high speed ball bearing were studied under a controlled environment. Results indicate that bearing speed appears to be a primary cause of increase of temperature and torque, with increasing oil flows and thrust loads being secondary causes of temperature and torque increase. Tests were run at speeds to  $1.8 \times 10^6$  DN (30,000 to 90,000 RPM). Rig design comparison for a given bearing environment requires considerable understanding of the bearing and keen judgment as to the value of each design parameter. (Author)

## A66-30405

IMPROVING THE ENDURANCE LIFE AND CORROSION PROTECTION PROVIDED BY SOLID FILM LUBRICANTS.

G. P. Murphy and F. S. Meade (U.S. Army, Weapons Command, Rock Island Arsenal, Rock Island, Ill.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 1C3. 20 p. 5 refs.  
Members, \$0.60; nonmembers, \$1.20.

Study of ways of improving the wear life and corrosion protection of solid film lubricants. The improved wear life and corrosion protection were obtained through the elimination of graphite and the addition of other lubricative pigments, using a pigment-to-resin ratio such that the pigment volume concentration is equal to the critical pigment volume concentration and increasing the film thickness to 0.0010 in. Such factors as lubricative pigments, pigment-to-binder ratios, degree of pigment dispersion, and effect of film thickness were studied. These factors have resulted in a Falex wear life of 700 to 800 min under a 1000-lb gage load and given corrosion protection (as determined by the 20% salt fog test) equal to that obtained with a good paint or to approximately 600 hr. M.F.

## A66-30406

A REVIEW OF THE PROPERTIES AND POTENTIALS OF THE NEW HEAVY METAL DERIVATIVE SOLID LUBRICANTS.

P. M. Magie (Bemol, Inc., Newton, Mass.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 2B3. 19 p. 16 refs.  
Members, \$0.60; nonmembers, \$1.20.

Review and comparison of the relatively new group of solid lubricants, the sulfides, selenides and tellurides of Groups IVB, VB, VIB, VIIIB, and some actinide metals. The physical and chemical properties of these compounds suggest new and broader uses for solid lubricants, particularly in the aerospace, electronics and instrumentation fields. Also discussed is the use of these new solid lubricants where vacuum-stable, electrically conducting lubricants with improved chemical and radiation stability are required. M.F.

## A66-30409

ADVANCED AEROSPACE GREASES.

J. B. Christian (USAF, Wright-Patterson AFB, Ohio) and K. R. Bunting (American Oil Co., Chicago, Ill.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 3C2. 16 p.  
Members, \$0.60; nonmembers, \$1.20.

Development and investigation of advanced grease lubricants for aerospace applications to determine their physical properties and their utility in space. The results of investigations conducted at 400°F, under vacuums of  $10^{-7}$  and  $10^{-9}$  torr have shown that the highly advanced greases can successfully lubricate both small- and large-diameter bearings operating at high speeds and under heavy loads for very long periods of time without relubrication. M.F.

## A66-30412

A THEORY OF LIQUID-SOLID HYDRODYNAMIC FILM LUBRICATION.

H. Grady Rylander (Texas, University, Mechanical Engineering Dept., Austin, Tex.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 5D3. 25 p. 14 refs.  
Members, \$0.60; nonmembers, \$1.20.  
NSF-supported research.

The investigation was undertaken for the purpose of extending the design theories for hydrodynamic bearings to include the effects of solid particles in a liquid base lubricant. A set of nonlinear, coupled partial differential equations is developed to include the effects of the solid particles. Solutions of the mathematical model by numerical analysis are compared to the results obtained in actual bearing tests using a universal bearing test machine. Increased friction from the solids is shown to be limited to a certain medium range of operation such that at Sommerfeld numbers above or below this range there is only a slight increase in the friction above that obtained with the liquid alone. Good agreement between the theoretical solutions and experimental values was obtained by using experimentally determined particle shear strengths. (Author)

## A66-30413

PREDICTION OF BALL-SPIN AND INTERFACIAL SLIP FRICTION FROM ROOM TO 2500 F.

A. R. Leveille, C. J. Zupkus, and H. R. Ludwig (General Motors Corp., Detroit, Mich.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 5D4. 37 p. 11 refs.  
Members, \$0.60; nonmembers, \$1.20.  
Contract No. AF 33(615)-1208.

Two materials, an intermetallic designated LT-2 and a stabilized formulation of zirconium oxide designated 1027-ZrO<sub>2</sub>, were tested in rolling friction studies from room to 2500°F. V-groove and circular groove tests were performed with resulting friction forces measured. The friction behaviors were correlated against previously established mathematical models. It was found that these models were adequate to predict observed friction behavior for the 1027-ZrO<sub>2</sub> material. The LT-2 material was found to experience a creep behavior which limited the accuracy of the models in the circular groove configuration when load and time at load were sufficient to cause noticeable creep. It is shown in a quantitative manner that the LT-2 creep behavior is sufficient to cause the observed deviation from the circular groove friction model. (Author)

## A66-30414

SNAP 8 REACTOR BEARING DEVELOPMENT.

L. G. Kellogg and W. G. Dewart (North American Aviation, Inc., Atomic International Div., Development and Product Operations Div., Canoga Park, Calif.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 7A1. 21 p. 9 refs.  
Members, \$0.60; nonmembers, \$1.20.  
AEC Contract No. AT (11-1)-GEN-8.

Description of a four-phase program that has successfully developed low-speed oscillating bearings, designed to provide low-friction self-lubrication at 1150°F while in the environment of a nuclear reactor operating in space. Phase I was the study and screen testing of static adhesion of bearing materials; phase II was the study and screen testing of bearing materials in sliding couple; phase III applied the materials to bearing designs where prototypes were fabricated and tested; and phase IV was the optimizing and testing of the final designs for reactor ground test in "poor" vacuum ( $10^{-5}$  torr), and simulated space-ultrahigh "clean" vacuum ( $10^{-9}$  torr). Results of shock and vibration tests are presented. F.R.L.

## A66-30415

STATUS OF LUBRICANTS FOR MANNED SPACECRAFTS.

F. G. A. de Laat, R. V. Shelton (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.), and J. H. Kimzey (NASA, Manned Spacecraft Center, Structures and Mechanics Div., Houston, Tex.).  
American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 7A2. 23 p. 7 refs.  
Members, \$0.60; nonmembers, \$1.20.

Discussion of lubricants selected for use on lunar missions and manned spacecraft, such as Apollo. Selection was primarily based on lubricant compatibility with oxygen-rich environment for crew compartment toxicity-odor hazard evaluations, lubricant-propellant compatibility investigations for long-exposure endurance, solid-dry-film lubricant compatibility with various anodic coatings, and studies of lubricant sliding-friction behavior in vacuum as encountered in

space. Several solid-dry-film lubricants were selected. Among the most outstanding greases was a completely polymeric perfluorinated material with a fluorocarbon-telomer thickener. F. R. L.

#### A66-30416

##### LUBRICANT LIFE TESTS ON BALL BEARINGS FOR SPACE APPLICATIONS.

Paul Lewis (Mechanical Technology, Inc., Latham, N.Y.), A. J. Babecki (NASA, Goddard Space Flight Center, Greenbelt, Md.), and S. F. Murray.

American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 7A3. 30 p. 5 refs. Members, \$0.60; nonmembers, \$1.20.

Contract No. NAS 5-9028.

An experimental program has been conducted to compare the effective lives of ball bearings operating in vacuum with various types of MoS<sub>2</sub> solid films, and with a special high vacuum oil, as lubricants. The test bearings were size 205 bearings running at 30 rpm under a 10-lb radial load. Two particular combinations were also evaluated in oscillating motion tests. Torque was used as the criterion for failure. Prior to test the bearings were subjected to a 2100-lb static load to simulate launch loading. The results of these tests showed that most of the solid film-lubricated bearings were effective for the first several hundred hours, then gave high and erratic torque values as the result of debris being formed by wear of the lubricant film. A sodium-silicate bonded solid lubricant film, which contained MoS<sub>2</sub> and graphite, was found to be particularly promising in both rotation and oscillation. One particularly significant finding was that the oil-lubricated bearings showed a sudden, large increase in torque after running effectively for about 1400 hr in vacuum. This behavior has often been predicted but has apparently never been observed experimentally, at least for rolling-contact bearings.

(Author)

#### A66-30568

##### FRICION AND WEAR OF HEXAGONAL METALS AND ALLOYS AS RELATED TO CRYSTAL STRUCTURE AND LATTICE PARAMETERS IN VACUUM.

Donald H. Buckley and Robert L. Johnson (NASA, Lewis Research Center, Cleveland, Ohio).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65-LC-18.)

ASLE Transactions, vol. 9, Apr. 1966, p. 121-132; Discussion, H. Wilman (London, University, Imperial College of Science and Technology, London, England), M. B. Peterson (Mechanical Technology, Inc., Latham, N.Y.), R. P. Steijn (Du Pont de Nemours and Co., Inc., Wilmington, Del.), p. 132-134; Authors' Closure, p. 134, 135. 40 refs.

[For abstract see issue 02, page 237, Accession no. A66-12252]

#### A66-30569

##### SLIDING BEHAVIOR OF SOME LAYER LATTICE COMPOUNDS IN ULTRAHIGH VACUUM.

A. J. Haltner (General Electric Co., Missile and Space Div., Space Sciences Laboratory, Philadelphia, Pa.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-19.)

ASLE Transactions, vol. 9, Apr. 1966, p. 136-146; Discussion, R. L. Johnson (NASA, Lewis Research Center, Cleveland, Ohio), W. A. Glaeser (Battelle Memorial Institute, Columbus, Ohio), and M. T. Lavik (Midwest Research Institute, Kansas City, Mo.), p. 146-148; Authors' Closure, p. 148. 28 refs.

Contract No. AF 33(657)-10493.

[For abstract see issue 02, page 237, Accession no. A66-12251]

#### A66-30570

##### THE EFFECT OF TIME, TEMPERATURE, AND ENVIRONMENT ON THE SLIDING BEHAVIOR OF POLYTETRAFLUOROETHYLENE.

R. P. Steijn (Du Pont de Nemours and Co., Inc., Engineering Research Div., Engineering Materials Laboratory, Wilmington, Del.), (American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper.)

ASLE Transactions, vol. 9, Apr. 1966, p. 149-157; Discussion, A. J. Haltner (General Electric Co., Missile and Space Div., Space Sciences Laboratory, Philadelphia, Pa.) and G. S. Reichenbach (Massachusetts Institute of Technology, Cambridge, Mass.), p. 157-159; Author's Closure, p. 159. 24 refs.

Contract No. AF 33(615)-1201.

Description of experimental observations pertinent to the following aspects of polytetrafluoroethylene (PTFE): (1) time effects during sliding tests; (2) sliding tests in dry nitrogen and other environments; and (3) friction tests with curved sliders. It is shown conclusively that the time at rest between sliding experiments has considerable bearing on the sliding speed of the next traverse. This is the same as saying that so-called equilibrium sliding speed depends on an arbitrary parameter. For PTFE sliding on PTFE, sliding velocity under a stationary friction force is influenced by (1) the time lapse between sliding experiments; (2) the nature of the preceding sliding experiment, especially its speed; and (3) the thermal history of the sliding components. For PTFE sliding on PTFE, prolonged experiments in dry nitrogen resulted in poor sliding behavior that was remedied by introducing air of 50% RH into the environment. This effect appears to be associated with the formation and subsequent behavior of wear detritus on the tract. Curved contact surfaces in sliding tests (crossed cylinders, sphere-on-flat) in addition to manifesting the effects listed above provide means of studying the relative roles that the adhesion and deformation components play in the sliding process.

M. F.

#### A66-30571

##### EFFECT OF VARIOUS LUBRICANTS AND BASE MATERIALS ON FRICTION AT ULTRAHIGH LOADS.

K. E. Demorest and A. F. Whitaker (NASA, Marshall Space Flight Center, Propulsion and Vehicle Engineering Laboratory, Materials Div., Huntsville, Ala.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-23.)

ASLE Transactions, vol. 9, Apr. 1966, p. 160-169; Discussion, D. H. Gaddis (Midwest Research Institute, Engineering Div., Kansas City, Mo.), p. 169, 170; Authors' Closure, p. 170. 5 refs.

[For abstract see issue 02, page 237, Accession no. A66-12249]

#### A66-30572

##### EXPERIMENTAL STUDY OF SPLINE WEAR AND LUBRICATION EFFECTS.

W. D. Weatherford, Jr., M. L. Valtierra, and P. M. Ku (Southwest Research Institute, San Antonio, Tex.).

(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper.)

ASLE Transactions, vol. 9, Apr. 1966, p. 171-178; Discussion, R. B. Waterhouse (Nottingham, University, Nottingham, England) and Douglas Godfrey (Chevron Research Co., Richmond, Calif.), p. 178; Authors' Closure, p. 178. 11 refs.

Contracts No. NOW-63-0511-d; No. NOW-64-0341-d.

The development of a laboratory method for simulating the wear experienced by misaligned splines is described, and typical experimental data are presented. The experimental program involves the use of matched spline specimens subjected to relative oscillatory motion simulating angular misalignment, under the influence of an applied torque. The test specimens are maintained at 250°F, either with or without lubrication, in the presence of dry air, moist air, JP-5 fuel, or JP-6 fuel. The extent of spline wear is quantitatively monitored on a continuous basis. The experimental results obtained with the above environments and seven different greases reveal significantly different wear mitigation characteristics for the various greases. Moreover, the influences of the spline environments differ for the different greases.

(Author)

**A66-30574****ANALYTICAL ASPECTS OF GEAR LUBRICATION ON THE DISENGAGING SIDE.**

J. W. McCain and E. Alsandor (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).  
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Preprint 65 LC-16.)  
ASLE Transactions, vol. 9, Apr. 1966, p. 202-210; Discussion, E. I. Radzimovsky (Illinois, University, Urbana, Ill.), p. 211.  
5 refs.  
[For abstract see issue 02, page 237, Accession no. A66-12253]

**A66-31392****THE EFFECT OF ALLOYING ELEMENTS ON THE CORROSION OF ALUMINIUM.**

K. F. Lorking (Department of Supply, Australian Defence Scientific Service, Aeronautical Research Laboratories, Melbourne, Australia).  
(Australasian Corrosion Association, Annual Conference, 6th, Melbourne, Australia, Nov. 15-19, 1965, Paper.)  
Australasian Corrosion Engineering, vol. 9, Oct. 1965, p. 3-7.  
10 refs.

Determination of the effect of the alloying elements copper, zinc, magnesium, silver, silicon, chromium and manganese on the corrosion of aluminum over a wide pH range in water and alkali and in 0.1N solutions of the anions chromate, benzoate, chloride, sulfate, and phosphate. The effect of the anion was found to be specific although chromate inhibited corrosion of all alloys. Alloying elements may be divided into two groups - those causing a significant but small increase in weight losses due to corrosion and those such as zinc, silver, and copper which cause a marked increase in corrosion weight losses.  
M. F.

**A66-31597****STUDY OF CORROSION OF METALS UNDER HEAT TRANSFER CONDITIONS.**

P. I. Zarubin, L. A. Poluboiartseva, and V. M. Novakovskii (Ural'skii Nauchno-Issledovatel'skii Khimicheskii Institut, Sverdlovsk; Nauchno-Issledovatel'skii Fiziko-Khimicheskii Institut, Moscow, USSR).  
(Zashchita Metallov, vol. 1, May-June 1965, p. 297-303.)  
Protection of Metals, vol. 1, May-June 1965, p. 259-264. 14 refs.  
Translation.  
[For abstract see issue 18, page 2658, Accession no. A65-29311]

**A66-31675 #****STUDY OF THE CHEMICAL STABILITY OF SOLID LUBRICANTS AT HIGH TEMPERATURES. I [ISSLEDOVANIIE KHIMICHESKOI USTOICHIVOSTI TVERDYKH SMAZOK PRI VYSOKIKH TEMPERATURAKH].**

M. E. Belitskii (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR).  
Poroshkovaia Metallurgii, vol. 6, Apr. 1966, p. 40-44. 7 refs.  
In Russian.

Study of the chemical stability of silver graphite, MoS<sub>2</sub>, ZnO, BN, and muscovite and phlogopite mica at high temperatures, in media of air, hydrogen, argon, and nitrogen. BN at temperatures to 800-900°C and phlogopite mica at higher temperatures are found to be solid lubricants that make better substitutes for graphite than the other materials studied.  
V. Z.

**A66-31899****DIFFERENTIAL THERMAL ANALYSIS FOR ESTIMATION OF THE RELATIVE THERMAL STABILITY OF LUBRICANTS.**

A. A. Krawetz and Theodore Tovrog (Phoenix Chemical Laboratory, Inc., Chicago, Ill.).  
I & EC - Industrial and Engineering Chemistry, Product Research and Development, vol. 5, June 1966, p. 191-198. 16 refs.  
Contract No. AF 33(657)-8771.

Demonstration of the applicability of the techniques of differential thermal analysis to the study of the thermal decomposition of organic lubricant systems. It is shown that the techniques of differential thermal analysis, applied at ambient as well as elevated

pressures, can be highly effective in the analysis of data by permitting a distinction to be made between pressure-dependent and pressure-independent reactions and by providing a means for the isolation of thermal effects due to decomposition reactions occurring at or near the normal boiling point of the sample being studied.  
A. B. K.

**A66-31932****FRICION AND DEFLECTION CHARACTERISTICS OF PTFE LINE BEARINGS.**

W. D. Craig, Jr. (Grumman Aircraft Engineering Corp., Mechanical Systems Section, Bethpage, N. Y.) and R. P. Remorenko (Fafnir Bearing Corp., New Britain, Conn.).  
Lubrication Engineering, vol. 22, May 1966, p. 181-186. 8 refs.

An experimental study was made of starting and kinetic friction of PTFE (polytetrafluoroethylene) fabric lined spherical bearings at loads between 1600 and 35,000 psi. Measurements of starting friction were made at temperatures between -200 and +255°F. Kinetic friction at room temperature was measured at sliding velocities between .0003 and .06 fps. Deflection and permanent set under static radial load were measured up to 36,600 psi. The lowest starting coefficient of friction occurred at loads around 10,000 psi from -100 to +255°F. Starting coefficient of friction varied as an exponential function of absolute temperature, showing a transition between 170 and 215°K that was dependent on load. The lowest transition temperature occurred in the 10,000 psi load range. Kinetic friction was relatively independent of velocity up to .0017 fps, increasing rapidly at higher velocities. From .003 to .06 fps, the coefficient of friction varied as an exponential function of velocity; at a given velocity the coefficient of friction decreased with an increase in load. Static deflection measurements up to loads of 36,500 psi showed that about 87% of the total radial deflection was recoverable after unloading.  
(Author)

**A66-31933****GRAPHITE LUBRICANT COMBINATIONS FOR HIGH TEMPERATURE APPLICATIONS.**

L. C. Lipp (Boeing Co., Seattle, Wash.) and E. N. Klemgard.  
Lubrication Engineering, vol. 22, May 1966, p. 187-195. 16 refs.  
Research sponsored by the Boeing Co.

Discussion of the high-temperature and -pressure lubrication properties of chemical and physical combinations of graphite with inorganic binders, metal halides, organic dyes, and inorganic polymers. It is thought that interaction of these materials in the interstitial positions and shearing edges of the graphite lattice to form intercalated edge compounds may account for the enhanced lubrication properties obtained above 1000°F. The combination of graphite with the inorganic polymer of phosphonitrilic chloride is found to be particularly effective in reducing friction and wear on an Ni-Cr-Co alloy. The coefficient of friction through the 100-to-1700°F range using this lubricant does not exceed 0.15. Modification of the graphite lattice by nuclear irradiation is proposed as a means of providing further improvement of high-temperature friction and wear of the graphite lubricants discussed.  
A. B. K.

**A66-31979****VAPOR DEPOSITED GOLD THIN FILMS AS LUBRICANTS IN VACUUM (10<sup>-11</sup> mm Hg).**

T. Spalvins and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).  
Journal of Vacuum Science and Technology, vol. 3, May-June 1966, p. 107-113. 17 refs.

Gold thin films of 1800 Å to be used as lubricants were vapor deposited on Ni, Ni-Cr, and Ni-Re substrates. Strong bonding (adhesion) and durability between the film and substrate were found to be essential when thin films are used as a lubricant. Factors that were investigated included the selection of the film and substrate material. Strong durability of the thin film is directly related to the type and structure of the interfacial region. Two methods of substrate preparation prior to vapor deposition were investigated: (1) mechanically polished surface and (2) electron bombarded surface. Gold was vapor deposited on the mechanically polished surface at room temperature and on the thermally etched surface at an elevated temperature approximately (800°F). Strength and durability of the films were investigated in sliding friction

experiments with a hemispherical niobium rider sliding on the films at a velocity of 5 ft/min. Results obtained in these friction experiments indicated that the film endurance life was considerably better on the thermally etched surface. This increased film durability with the thermally etched surface is believed to be owing to the formation of a diffusion type interface between the film and the substrate. Because of the disregistry at grain boundaries, a higher rate of diffusion and preferential trapping in and around the grain boundaries occurs, with these regions acting as lubricant reservoirs during the friction experiments. (Author)

#### A66-32605 =

DAMPING OF OSCILLATIONS OF GYROSCOPE ROTORS EMPLOYING SLIDING BEARINGS [DEMPFIROVANIE KOLEBANII GYROSKOPICHESKIKH ROTOROV S PODSHIPNIKAMI SKOL'ZHENIYA].

S. I. Sergeev.

*Inzhenernyi Zhurnal - Mekhanika Tverdogo Tela*, Mar.-Apr. 1966, p. 189, 190. In Russian.

Discussion of rotor oscillations excited by the effect of the lubricant layer in plain bearings under the effect of the gyroscopic moment of rotor inertia. The stability of motion is analyzed for an unloaded symmetrical rigid rotor rotating in lubricated cylindrical plain bearings mounted on elastically damped supports. V. P.

#### A66-33143 =

OPERATING LIFETIME OF POROUS BEARINGS AS A FUNCTION OF THE GRADE OF THE IMPREGNATING LUBRICANT [O DLITEL'NOSTI RABOTY PORISTYKH PODSHIPNIKOV V ZAVISIMOSTI OT SORTA PROPITYVAYUSHCHIKH SMAZOK].

V. D. Zozulia (Akademiia Nauk Ukrainskoi SSR, Institut Problem Materialovedeniia, Kiev, Ukrainian SSR).

*Poroshkovaia Metallurgiiia*, vol. 6, May 1966, p. 103-106. 5 refs. In Russian.

Estimate of the lifetime of self-lubricating, porous bearings. The dependence of the lifetime on the grade of the lubricant used to impregnate the bearings is determined. R. A. F.

#### A66-33178 =

THE STEADY-STATE AND DYNAMIC CHARACTERISTICS OF A FULL CIRCULAR BEARING AND A PARTIAL ARC BEARING IN THE LAMINAR AND TURBULENT FLOW REGIMES.

F. K. Orcutt and E. B. Arwas (Mechanical Technology, Inc., Latham, N. Y.).

*American Society of Mechanical Engineers, Lubrication Symposium*, New Orleans, La., June 5-9, 1966, Paper 66-LubS-4. 11 p. 13 refs.

Members, \$0.75; nonmembers, \$1.50.

Contract No. NASw-771.

The steady-state and dynamic characteristics of a full circular bearing and a centrally loaded, 100-deg. arc bearing are calculated for a range of eccentricity ratios to 0.95 and of mean Reynolds numbers to 13,300, and presented in design charts. These are compared with the measured performance of these bearings over the same ranges of the operating parameters. There is good correlation between the theoretical and test data, leading to the conclusion that the present turbulent lubrication analysis may be used to obtain general design data for self-acting bearings, operating in the super-laminar flow regime, to supplement that presently existing for laminar flow bearings. (Author)

#### A66-33181 =

THE MHD HYDROSTATIC THRUST BEARING - THEORY AND EXPERIMENTS.

R. J. Krieger, H. J. Day, and W. F. Hughes (Carnegie Institute of Technology, Pittsburgh, Pa.).

*American Society of Mechanical Engineers, Lubrication Symposium*, New Orleans, La., June 5-9, 1966, Paper 66-LubS-8. 7 p. Members, \$0.75; nonmembers, \$1.50.

An analytical and experimental investigation is made of magneto hydrodynamic lubrication flow between parallel stationary disks in an axial magnetic field. The effect of the fluid inertia is analyzed by a single iteration of the appropriate differential equations. For a given pressure, the approximate solution indicates that the inertia forces increase the load capacity and flow rate. Experimental flow rates are obtained by varying the Hartmann number with a constant

head and by varying the head with a constant Hartmann number. Good agreement is found between the theory and experimental results until the transition to turbulent flow occurs. The effect of the magnetic field on this transition is evident from the data. (Author)

#### A66-33182 =

EFFECTS OF ROUGHNESS IN HYDROMAGNETICALLY LUBRICATED BEARINGS.

J. B. Shukla (Institute of Higher Technology, Kanpur, India) and R. Prasad (V.S. Sanatan Dharam College, Kanpur, India).

*American Society of Mechanical Engineers, Lubrication Symposium*, New Orleans, La., June 5-9, 1966, Paper 66-LubS-9. 5 p. Members, \$0.75; nonmembers, \$1.50.

In this paper, the effects of surface roughness are considered in the following two cases: (1) hydromagnetically lubricated externally pressurized bearings; and (2) hydromagnetic squeeze film between two circular plates. For sufficiently rough surfaces, it is shown that the load capacity mainly depends upon the amplitudes of the roughness waves, and the contribution to the load capacity due to roughness increases as the strength of the magnetic field increases. (Author)

#### A66-33183 =

GAS TURBINE BALL BEARING DESIGN.

C. C. Moore (General Electric Co., Flight Propulsion Div., Advanced Engine and Technology Dept., Evendale, Ohio).

*American Society of Mechanical Engineers, Lubrication Symposium*, New Orleans, La., June 5-9, 1966, Paper 66-LubS-10. 13 p. 13 refs.

Members, \$0.75; nonmembers, \$1.50.

The design of split-inner-race ball bearings for use as thrust bearings on aircraft gas turbines is discussed. These bearings normally operate at a 1 to 1.5 x 10<sup>6</sup> DN value (bore in mm x speed in rpm) and are lubricated and cooled by oil jets. For a given set of conditions, a bearing of suitable life to fit the shaft is designed and a vendor drawing is presented to permit manufacture. Bearing heat generation and oil flow are calculated and the effect of multiple bearing lives on overall system life is discussed. (Author)

#### A66-33184 =

A COMPARISON OF TURBULENT LUBRICATION THEORIES AND A SOLUTION OF CONSTANTINESCU'S EQUATION FOR A FINITE-LENGTH BEARING.

J. A. Edwards, J. U. Crowder, T. K. Mann, Jr. (North Carolina University, North Carolina State, Engineering Mechanics Dept., Raleigh, N. C.), and J. P. Lamb (Texas University, Mechanical Engineering Dept., Austin, Tex.).

*American Society of Mechanical Engineers, Lubrication Symposium*, New Orleans, La., June 5-9, 1966, Paper 66-LubS-11. 13 p. 16 refs.

Members, \$0.75; nonmembers, \$1.50.

This paper presents a numerical solution of the Constantinescu equation of turbulent hydrodynamic lubrication for a finite-length journal bearing. A critical review of the present state of knowledge of turbulent hydrodynamic lubrication is offered. The theories proposed by Smith and Fuller, Tao, Chou and Saibel, and Constantinescu are examined in regard to their conformity with one another and with the data of Smith and Fuller. It is tentatively concluded that the approach of Constantinescu is the most promising formulation upon which to base further research. The value of the empirical constant which best fits the numerical solution to the data of Smith and Fuller is found to be considerably less than that suggested by Constantinescu. Further, the centerline pressure distribution of the numerical solution deviates appreciably from that measured by Smith and Fuller. (Author)

#### A66-33185 =

THE NUMERICAL SOLUTION OF A SPECIAL HILL EQUATION IN LUBRICATION THEORY.

Donald F. Hays (General Motors Corp., Research Laboratories, Mechanical Development Dept., Warren, Mich.).

*American Society of Mechanical Engineers, Lubrication Symposium*, New Orleans, La., June 5-9, 1966, Paper 66-LubS-13. 11 p. 26 refs.

Members, \$0.75; nonmembers, \$1.50.

The heretofore untabulated eigenvalues and eigenvectors of a special Hill equation are obtained through the use of numerical techniques. This Hill equation is generated when the method of separation of variables is used to achieve a formal solution for the Reynolds equation as applied to finite journal bearings. To illustrate the numerical methods, the specific example of a complete journal bearing is taken and the results compared with previously recorded values. The first fifteen eigenvalues are computed for the odd and even eigenvectors of the Hill equation. These eigenvectors are defined over the region  $(-\pi, \pi)$  at intervals of  $\pi/90$ . (Author)

#### A66-33186 \*

#### IMPROVED METHOD FOR NUMERICAL SOLUTIONS OF THE GENERAL INCOMPRESSIBLE FLUID FILM LUBRICATION PROBLEM.

V. Castelli (Columbia University, New York, N.Y.) and W. Shapiro (Franklin Institute, Research Laboratories, Philadelphia, Pa.). American Society of Mechanical Engineers, Lubrication Symposium, New Orleans, La., June 5-9, 1966, Paper 66-LubS-14. 9 p. Members, \$0.75; nonmembers, \$1.50.

Research sponsored by the Franklin Institute.

A numerical analysis for determining performance characteristics of hydrodynamic, hydrostatic, or hybrid bearings with arbitrary clearance distribution is presented. Solution of the Reynolds lubrication equation for incompressible fluids is achieved by formation of coefficient matrices that act upon column vectors of the pressures progressively from one boundary to the other without requiring an iterative scheme. Multiple recesses are handled by component solutions. The external supply system is included and solved for an arbitrary type of individual recess compensation and supply circuit network. Sample results are indicated. (Author)

#### A66-33426

AIR CONTAMINATION IN TITANIUM ALLOYS Ti-679 AND Ti-8-1-1. K. C. Antony (General Electric Co., Flight Propulsion Div., Advanced Engine and Technology Dept., Cincinnati, Ohio). American Society for Testing and Materials, Pacific Area National Meeting, 5th, Seattle, Wash., Oct. 31-Nov. 5, 1965, Paper. Journal of Materials, vol. 1, June 1966, p. 456-477. 13 refs.

The oxidation characteristics of titanium alloys Ti-679 and Ti-8Al-1Mo-1V were determined using conventional weight-gain techniques. The air oxidation of both alloys followed parabolic rate laws at 1000 and 1100°F. Metal losses (spalling) were excessive in the Ti-679 alloy at higher temperatures. The static weight-gain measurements were supplemented with metallographic, electron-microscopic, and X-ray diffraction analyses. An outer scale identified as rutile titanium oxide ( $\text{TiO}_2$ ) and an inner subscale characterized by interstitial contamination were noted. The interstitial distribution in the subscale and core was measured indirectly, and oxygen diffusion rates were calculated. The diffusion of oxygen in the alpha allotropes of Ti-679 and Ti-8-1-1 were expressed best as  $D(\text{Ti-679}) = 0.12 \exp -48,000/RT$  and  $D(\text{Ti-8-1-1}) = 1.20 \exp -52,300/RT$ , respectively. The extent of combined scale/subscale reaction was generally greater in Ti-679 than in Ti-8-1-1. However, these scale/subscale reactions were quite limited in both alloys compared to specimen bulk. The tensile properties of Ti-679 and Ti-8-1-1 were measured after exposure in the temperature range 700 to 1100°F. Tensile ductility was decreased significantly under sufficiently severe exposure conditions. Parametric correlation of the times and temperatures necessary for oxidation embrittlement were proposed. (Author)

#### A66-33440

STRESS CORROSION, DELAYED FAILURES, FATIGUE CORROSION AND RELATIONS BETWEEN THESE PHENOMENA; COMMISSARIAT A L'ENERGIE ATOMIQUE, METALLURGICAL COLLOQUIUM, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS [CORROSION SOUS CONTRAINTE, RUPTURES DIFFEREES, FATIGUE-CORROSION ET RELATIONS ENTRE CES PHENOMENES; COMMISSARIAT A L'ENERGIE ATOMIQUE, COLLOQUE DE METALLURGIE, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS]. Paris, Presses Universitaires de France, 1965. 145 p. \$10.15.

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INTRODUCTION. Georges Chaudron. 1 p.  
EMBRITTEMENT OF TANTALUM BY HYDROGEN AT ROOM TEMPERATURE [FRAGILISATION DU TANTALE PAR L'HYDROGENE, A TEMPERATURE AMBIANTE]. M. A. Clauss (Strasbourg, Université, Strasbourg, France), p. 29-39. 10 refs. [See A66-33441 17-17]

OBSERVATIONS OF DELAYED FAILURES IN STAINLESS STEEL USED FOR BOLTS [OBSERVATIONS SUR LES RUPTURES DIFFEREES D'ACIERS INOXYDABLES DE BOULONNERIE]. M. Weisz, P. Le Bret, G. Brionne, G. Allegraud, and G. Didout (Commissariat à l'Energie Atomique, Gif-sur-Yvette, Seine-et-Oise, France), p. 41-56. 8 refs. [See A66-33442 17-17]

PRESENT STATE OF KNOWLEDGE OF FATIGUE CORROSION IN METALS [CONNAISSANCES ACTUELLES SUR LA FATIGUE-CORROSION DES METAUX]. A. Royez (Usines Renault, Boulogne-Billancourt, Seine, France), p. 95-110. 21 refs. [See A66-33443 17-17]

DISLOCATION DISTRIBUTION AND CRACK FORMATION UNDER STRESS CORROSION [LA DISTRIBUTION DES DISLOCATIONS ET LA FORMATION DES FISSURES PAR CORROSION SOUS TENSION]. J. Nutting (Leeds, University, Leeds, England), p. 111-116. 7 refs. [See A66-33444 17-17]

AUSTENITIC STAINLESS STEELS RESISTANT TO STRESS CORROSION [ACIERS INOXYDABLES AUSTENITIQUES RESISTANT A LA CORROSION SOUS TENSION]. J. Hochmann (Compagnie des Ateliers et Forges de la Loire, Unieux, Loire, France), p. 127-133. 13 refs. [See A66-33445 17-17]

CONCLUSION. Georges Chaudron, p. 143, 144.

#### A66-33441

EMBRITTEMENT OF TANTALUM BY HYDROGEN AT ROOM TEMPERATURE [FRAGILISATION DU TANTALE PAR L'HYDROGENE, A TEMPERATURE AMBIANTE]. M. A. Clauss (Strasbourg, Université, Laboratoire de Chimie Générale, Strasbourg, France).

IN: STRESS CORROSION, DELAYED FAILURES, FATIGUE CORROSION AND RELATIONS BETWEEN THESE PHENOMENA; COMMISSARIAT A L'ENERGIE ATOMIQUE, METALLURGICAL COLLOQUIUM, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS [CORROSION SOUS CONTRAINTE, RUPTURES DIFFEREES, FATIGUE-CORROSION ET RELATIONS ENTRE CES PHENOMENES; COMMISSARIAT A L'ENERGIE ATOMIQUE, COLLOQUE DE METALLURGIE, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS]. [A66-33440 17-17]

Paris, Presses Universitaires de France, 1965, p. 29-38; Discussion, p. 38, 39. 10 refs. In French.

Study of the abnormal brittleness exhibited by tantalum when it is deformed in the presence of hydrogen. It was found that the appearance of brittleness depends on the presence of oxygen dissolved in the tantalum lattice. The effects of the rate of deformation and of the dissolved oxygen content are defined. A comparable brittleness is observed when nitrogen is substituted for oxygen in the tantalum lattice. D. P. F.

#### A66-33442

OBSERVATIONS OF DELAYED FAILURES IN STAINLESS STEEL USED FOR BOLTS [OBSERVATIONS SUR LES RUPTURES DIFFEREES D'ACIERS INOXYDABLES DE BOULONNERIE]. M. Weisz, P. Le Bret, G. Brionne, G. Allegraud (Commissariat à l'Energie Atomique, Centre d'Etudes Nucleaires de Saclay, Département de Metallurgie, Services Technologie, Section d'Etude des Metaux de Structure, Gif-sur-Yvette, Seine-et-Oise, France), and G. Didout (Commissariat à l'Energie Atomique, Centre d'Etudes Nucleaires de Saclay, Département de Metallurgie, Services Technologie, Section d'Etude des Alliages d'Uranium, Gif-sur-Yvette, Seine-et-Oise, France).

IN: STRESS CORROSION, DELAYED FAILURES, FATIGUE CORROSION AND RELATIONS BETWEEN THESE PHENOMENA; COMMISSARIAT A L'ENERGIE ATOMIQUE, METALLURGICAL COLLOQUIUM, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS [CORROSION SOUS CONTRAINTE, RUPTURES DIFFEREES, FATIGUE-CORROSION ET RELATIONS ENTRE CES PHENOMENES; COMMISSARIAT A L'ENERGIE

ATOMIQUE, COLLOQUE DE METALLURGIE, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS]. [A66-33440 17-17]

Paris, Presses Universitaires de France, 1965, p. 41-55; Discussion, De Leiris and P. Bastien (Etablissements Schneider, Paris, France), p. 55, 56. 8 refs. In French.

Definitions of the concepts of stress level for crack initiation and for crack propagation using delayed failure tests with samples which were simultaneously subjected to tensile loading and cathode charging with hydrogen. It is found that while the stress required for crack initiation appears to depend only on the structure, the rate of crack propagation is also dependent on experimental factors - such as temperature and current density - which determine the rate of hydrogen penetration and its diffusion in the metal. D.P.F.

#### A66-33443

PRESENT STATE OF KNOWLEDGE OF FATIGUE CORROSION IN METALS [CONNAISSANCES ACTUELLES SUR LA FATIGUE-CORROSION DES METAUX].

A. Royez (Usines Renault, Régie Nationale, Direction des Recherches, Boulogne-Billancourt, Seine, France).

IN: STRESS CORROSION, DELAYED FAILURES, FATIGUE CORROSION AND RELATIONS BETWEEN THESE PHENOMENA; COMMISSARIAT A L'ENERGIE ATOMIQUE, METALLURGICAL COLLOQUIUM, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS [CORROSION SOUS CONTRAINTE, RUPTURES DIFFEREES, FATIGUE-CORROSION ET RELATIONS ENTRE CES PHENOMENES; COMMISSARIAT A L'ENERGIE ATOMIQUE, COLLOQUE DE METALLURGIE, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS]. [A66-33440 17-17]

Paris, Presses Universitaires de France, 1965, p. 95-109; Discussion, p. 109, 110. 21 refs. In French.

Study of the simultaneous and synergistic action of dynamic stresses and corrosive media in which it is shown that the mechanism of such action is electrochemical and that oxygen plays an important role. It is shown that certain parts of a metal component act as an anode and provide the starting point for fissures of an intergranular type. Fatigue resistance appears to be of less importance than corrosion resistance. The role of dynamic stresses is to break up protective films and to propagate cracks. D.P.F.

#### A66-33444

DISLOCATION DISTRIBUTION AND CRACK FORMATION UNDER STRESS CORROSION [LA DISTRIBUTION DES DISLOCATIONS ET LA FORMATION DES FISSURES PAR CORROSION SOUS TENSION].

J. Nutting (Leeds, University, Leeds, England).

IN: STRESS CORROSION, DELAYED FAILURES, FATIGUE CORROSION AND RELATIONS BETWEEN THESE PHENOMENA; COMMISSARIAT A L'ENERGIE ATOMIQUE, METALLURGICAL COLLOQUIUM, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS [CORROSION SOUS CONTRAINTE, RUPTURES DIFFEREES, FATIGUE-CORROSION ET RELATIONS ENTRE CES PHENOMENES; COMMISSARIAT A L'ENERGIE ATOMIQUE, COLLOQUE DE METALLURGIE, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS]. [A66-33440 17-17]

Paris, Presses Universitaires de France, 1965, p. 111-115; Discussion, H. Coriou (Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Saclay, Département de Chimie, Service d'Etude de la Corrosion Aqueuse et d'Electrochimie, Gif-sur-Yvette, Seine-et-Oise, France), Salesse (Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Saclay, Département de Metallurgie, Gif-sur-Yvette, Seine-et-Oise, France), Plateau, and T. P. Hoar (Cambridge, Université, Département de Metallurgie, Cambridge, England), p. 115, 116. 7 refs. In French.

Study of the phenomena related to the distribution of dislocations and cracks caused by stress corrosion. Under low stresses cumulative dislocations occur only at the grain boundaries and crack linking leads to intercrystalline failure. Under high stresses dislocation groups are formed along the slip planes and the pits at individual dislocation sites link up to form transcrystalline cracks. D.P.F.

#### A66-33445

AUSTENITIC STAINLESS STEELS RESISTANT TO STRESS CORROSION [ACIERS INOXYDABLES AUSTENITIQUES RESISTANT A LA CORROSION SOUS TENSION].

J. Hochmann (Compagnie des Ateliers et Forges de la Loire, Département des Recherches, Unieux, Loire, France).

IN: STRESS CORROSION, DELAYED FAILURES, FATIGUE CORROSION AND RELATIONS BETWEEN THESE PHENOMENA; COMMISSARIAT A L'ENERGIE ATOMIQUE, METALLURGICAL COLLOQUIUM, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS [CORROSION SOUS CONTRAINTE, RUPTURES DIFFEREES, FATIGUE-CORROSION ET RELATIONS ENTRE CES PHENOMENES; COMMISSARIAT A L'ENERGIE ATOMIQUE, COLLOQUE DE METALLURGIE, 8TH, CADARACHE, RHONE, FRANCE, JUNE 25, 26, 1964, PROCEEDINGS]. [A66-33440 17-17]

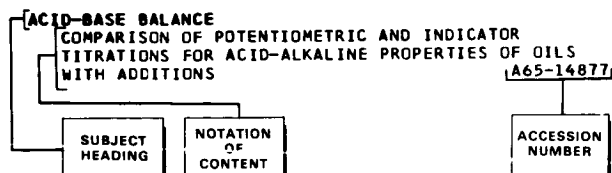
Paris, Presses Universitaires de France, 1965, p. 127-132; Discussion, p. 132, 133. 13 refs. In French.

Examination of the effect of surface finishing on the stress corrosion resistance of austenitic stainless steels. It is found that the worst surfaces are those obtained by mechanical working, grinding, or polishing. Chemical pickling lowers the sensitivity to corrosion. Sand blasting or shot peening gives rise to compressive stresses which prevent cracking. Stable austenites are more prone to stress corrosion after cold working; pseudomartensitic structures obtained by deformation have a better resistance to this type of corrosion. D.P.F.

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## ATMOSPHERIC CIRCULATION

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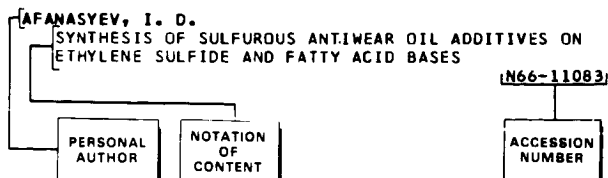
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